

Ansys ModelCenter MBSE

Supporting Digital Mission Engineering through Integrated Modeling and Simulation

INCOSE Huntsville

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The Ansys logo consists of a stylized yellow 'A' followed by the word 'Ansys' in a bold, black, sans-serif font.

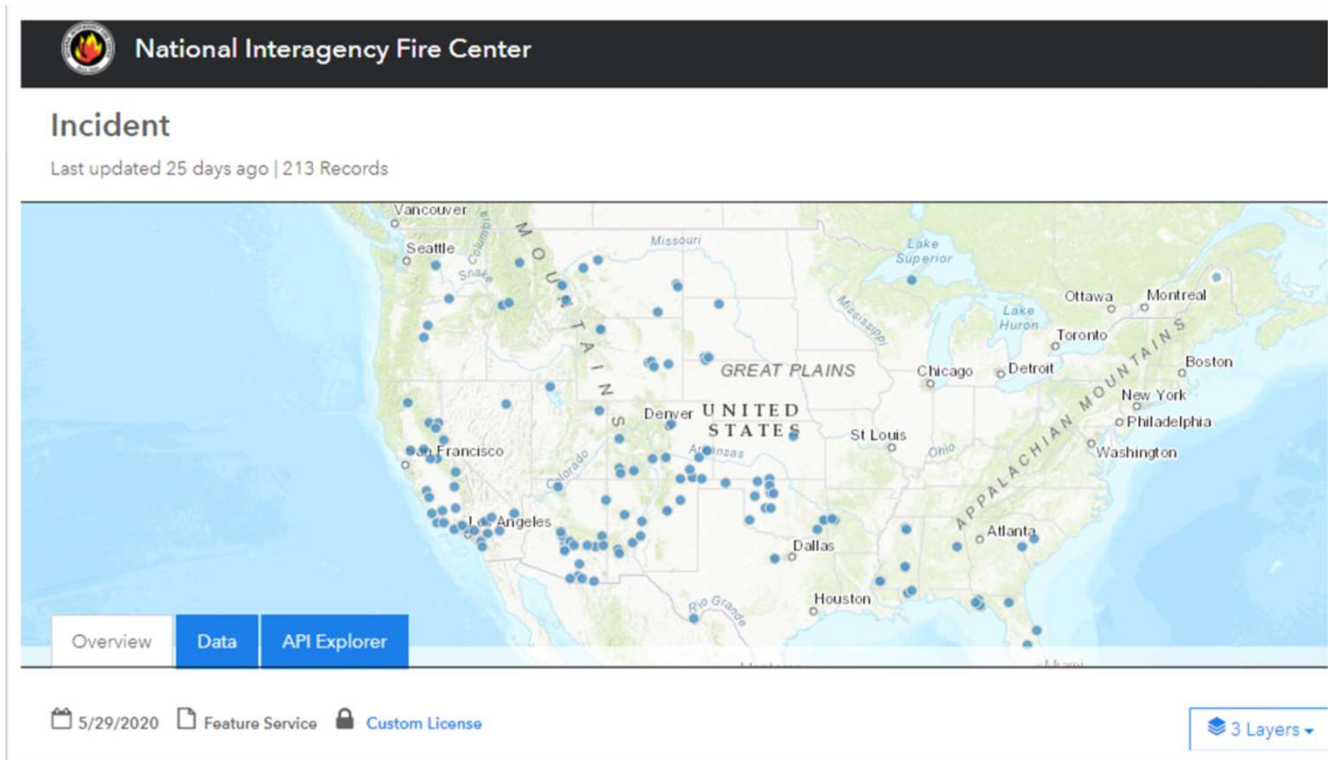
ModelCenter®

Demonstration of ModelCenter MBSE



Demo Objective

Define a system of systems that detects and communicates the existence of wildfires in "real time"



Demo Agenda

1. **DME Models** - Review the STK, ANSYS, Excel, and Cameo models
2. **Integrate DME Models** - Integrate DME models into ModelCenter workflow
3. **Integrate MBSE Model** - Connect ModelCenter workflow to Cameo SysML model
4. **Increase Model Fidelity** - Increase the fidelity of the antenna pattern for STK
5. **Requirement Changes** - Handle requirement changes to the SysML model



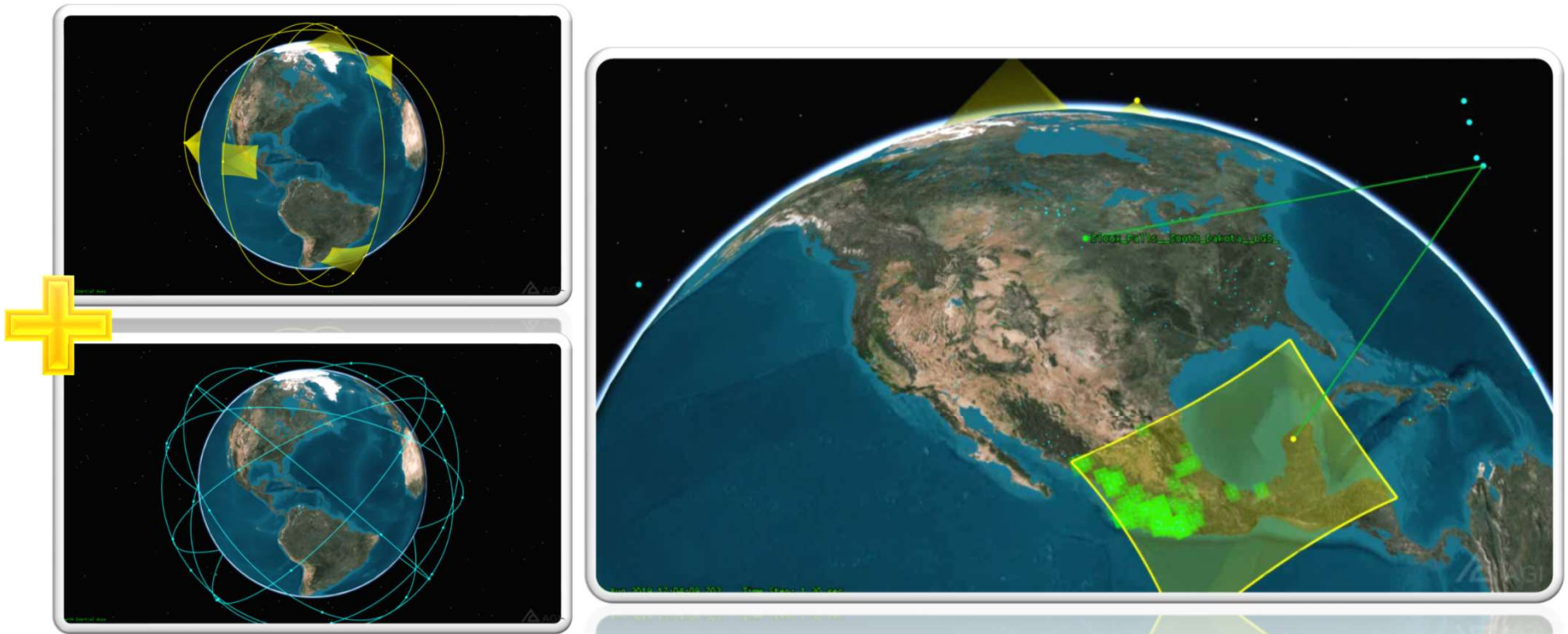
**Review the STK, ANSYS,
Excel, and Cameo models**



ANSYS

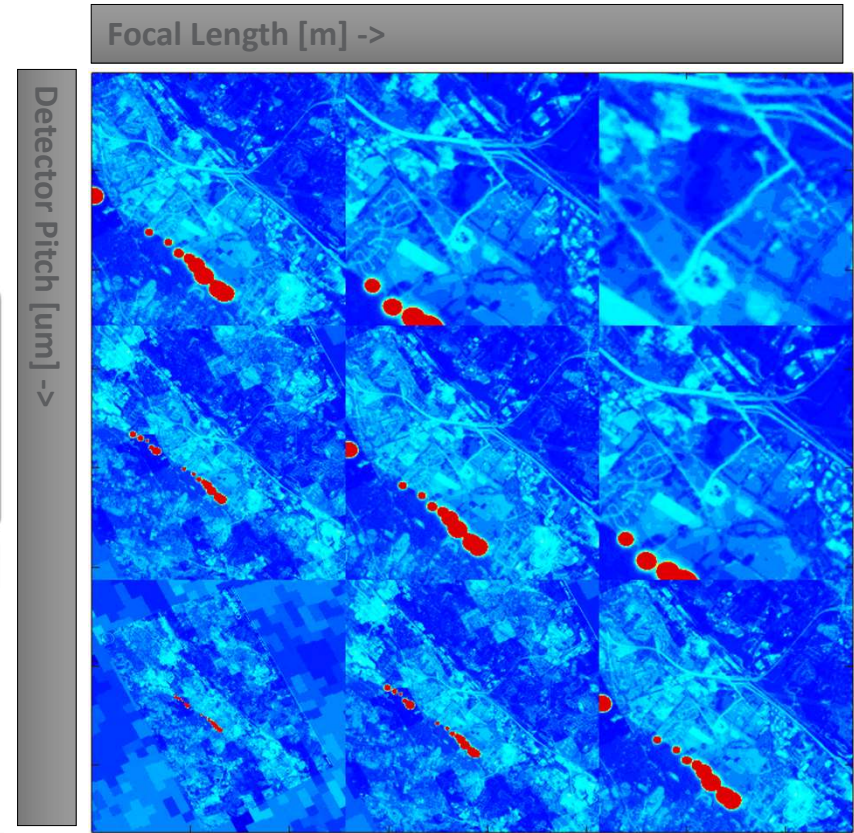
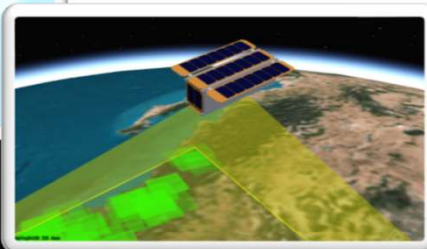
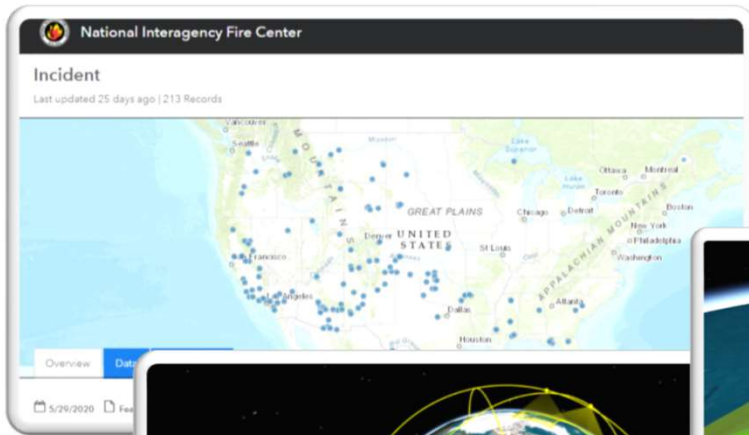
/ The Mission

- Detect and Communicate Wildfires



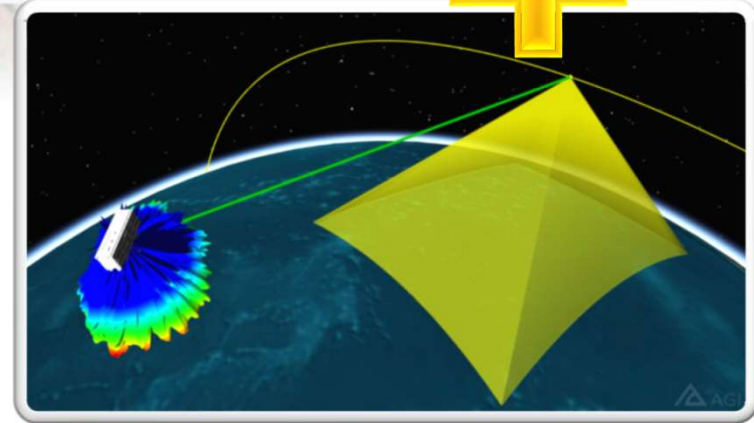
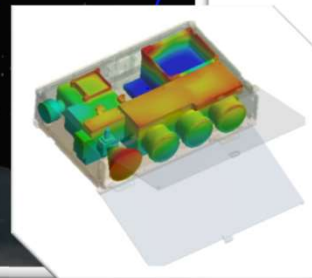
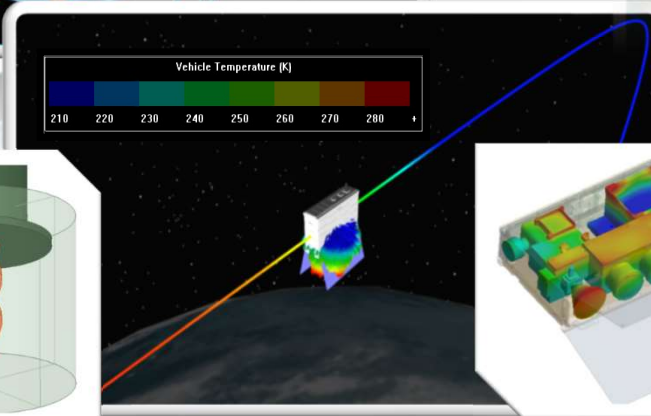
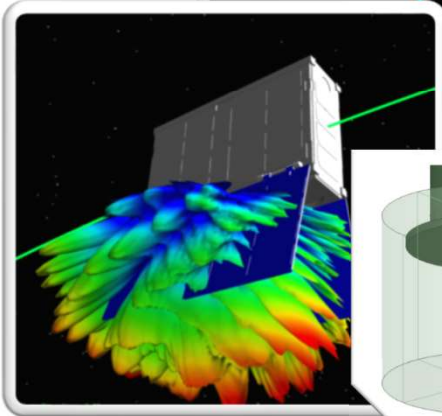
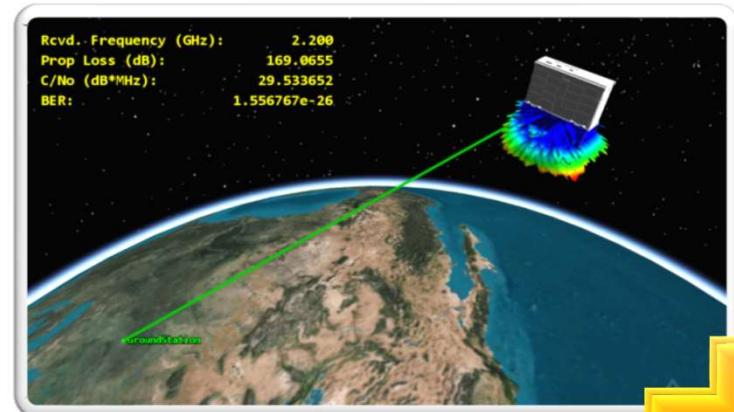
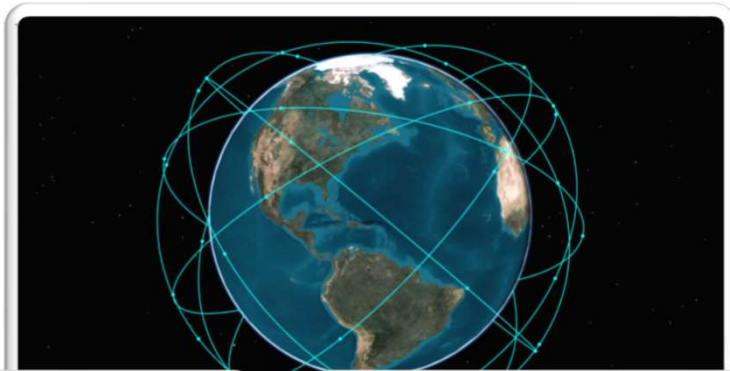
/ Detecting Wildfires

- Sensing Constellation



Communications

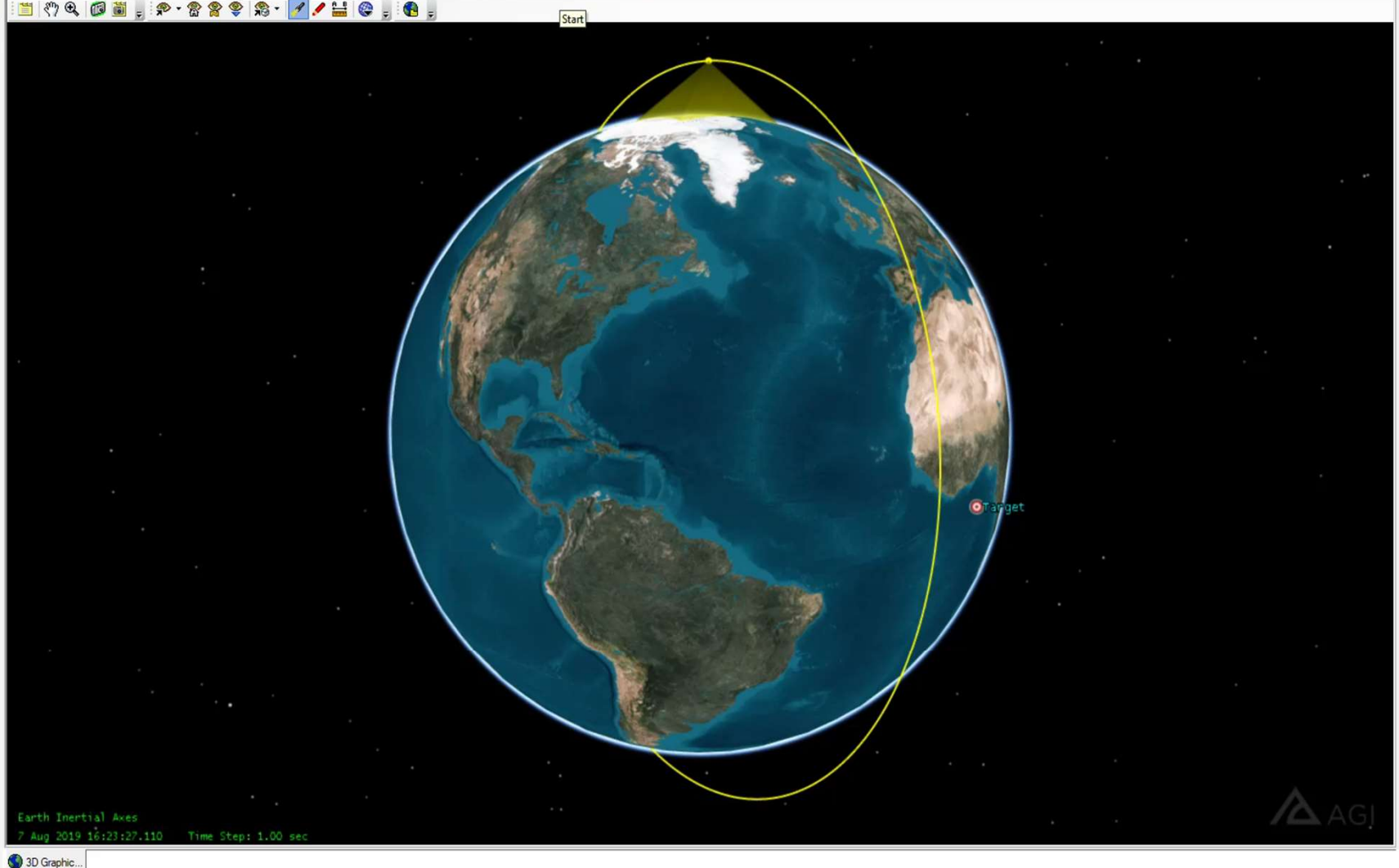
- Relay Constellation



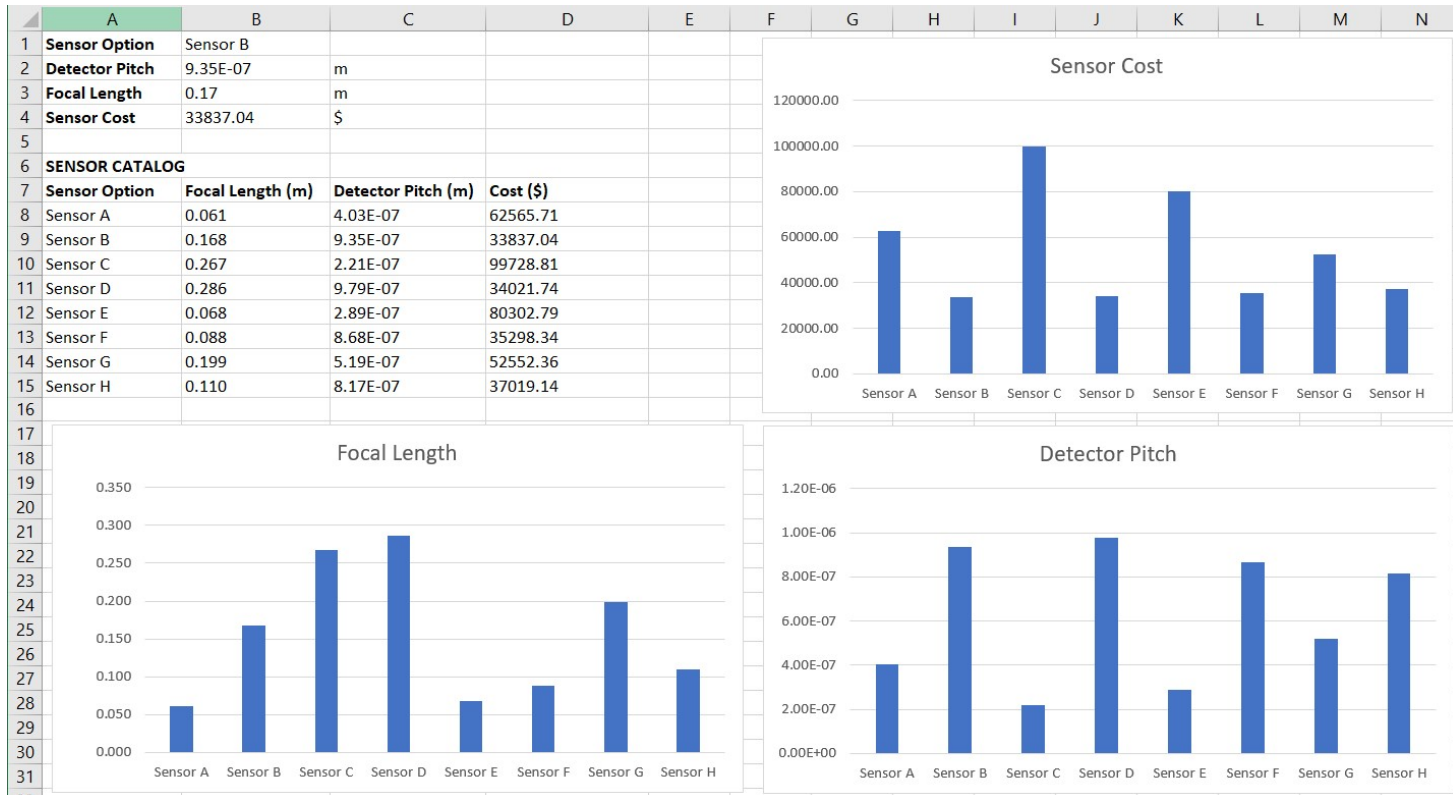
Mission Requirements

1. The sensing system shall collect imagery with a **ground sample distance** less than **10 meters** in order to detect any wildfire in North America greater than 2 acres
2. The communications system shall provide link availability with less than **7.5% outage** which corresponds roughly to one orbital period per day
3. Overall system **revisit time** shall be less than **4 hours** to support an adequate response time
4. **Total cost** shall be less than **\$130 million**

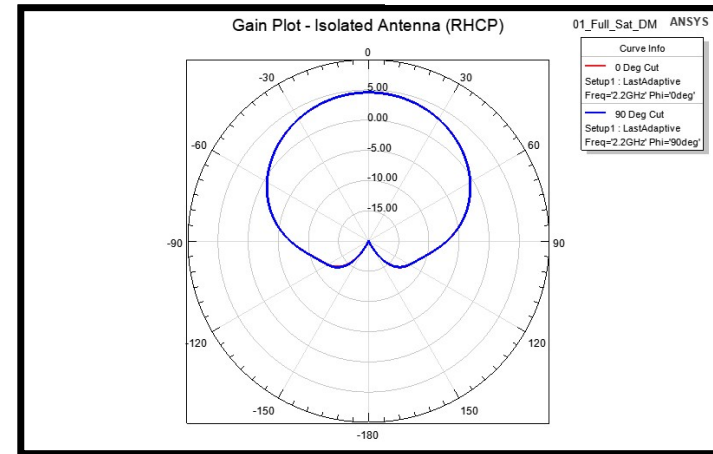
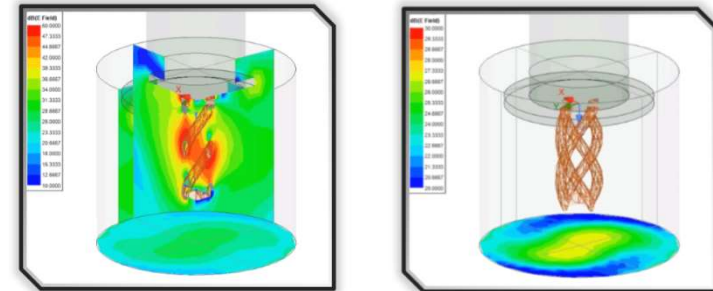
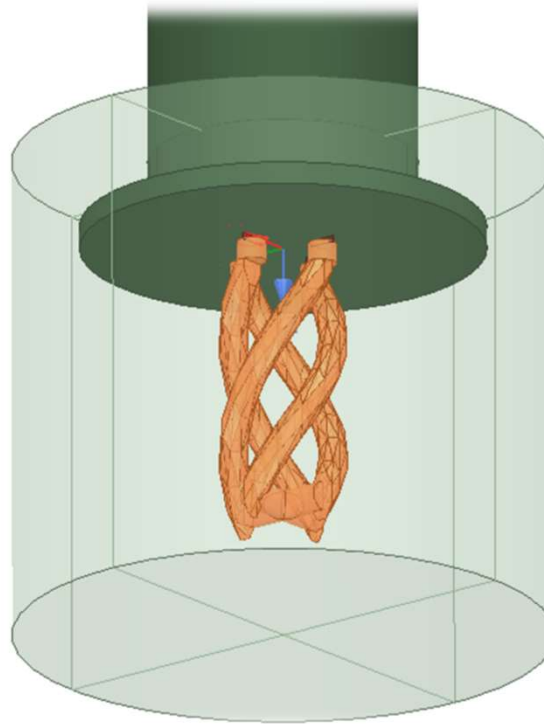
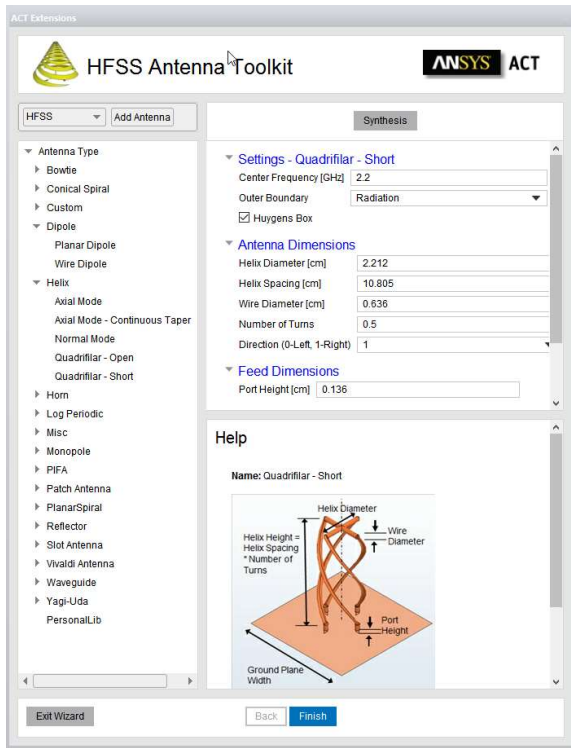
- Object Browser
- LayeredConstellation
 - senseToComms
 - senseToCommsIdeal
 - CommsShell
 - CommsShellSats
 - GroundC2
 - SatSensors
 - SensingShellComms
 - SensorShell
 - CoverageDefinition
 - Gilmore_Creek_Alaska_GLC_
 - Sioux_Falls_South_Dakota_LGS_
 - commSat
 - commSat11
 - commSat12
 - commSat13
 - commSat14
 - commSat15
 - commSat16
 - commSat17
 - commSat21
 - commSat22
 - commSat23
 - commSat24
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 - commSat36
 - commSat37
 - commSat41
 - commSat42
 - commSat43
 - commSat44
 - commSat45
 - commSat46
 - commSat47
 - commSat51
 - commSat52
 - commSat53
 - commSat54
 - commSat55



Sensor Catalog Spreadsheet

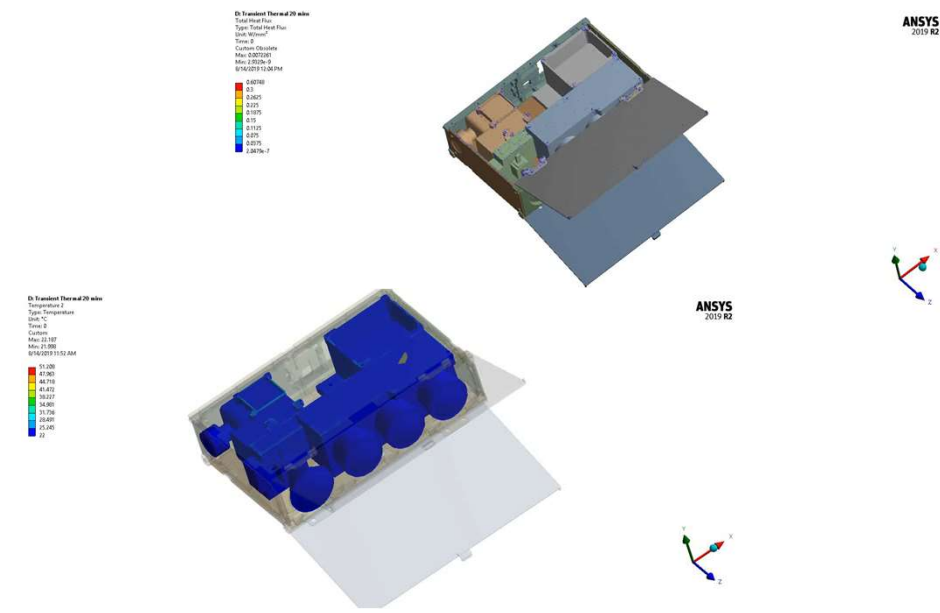
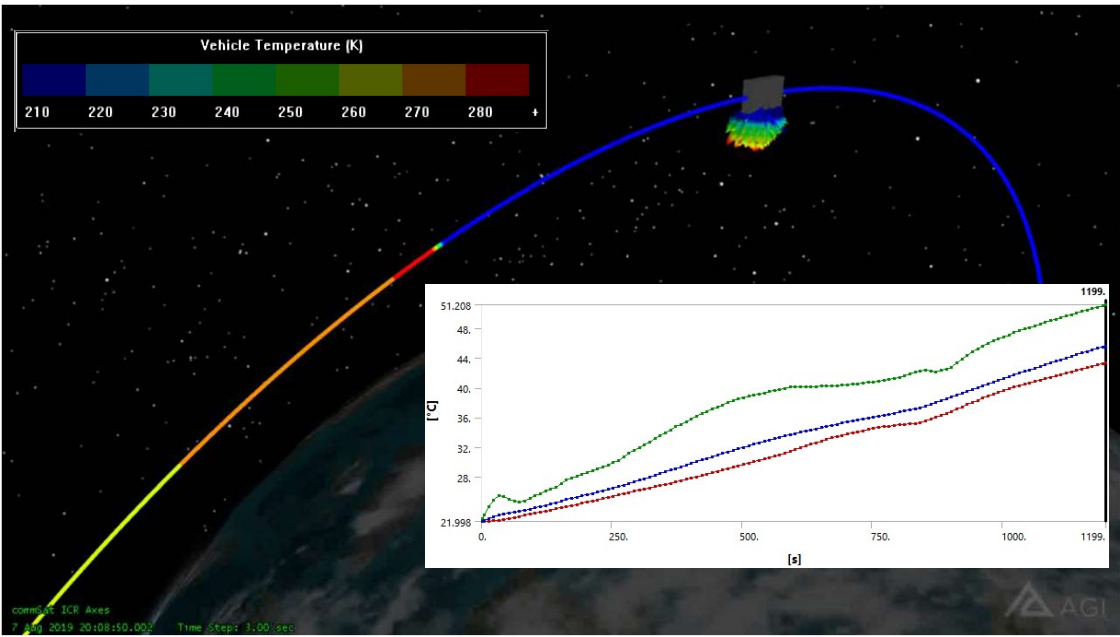
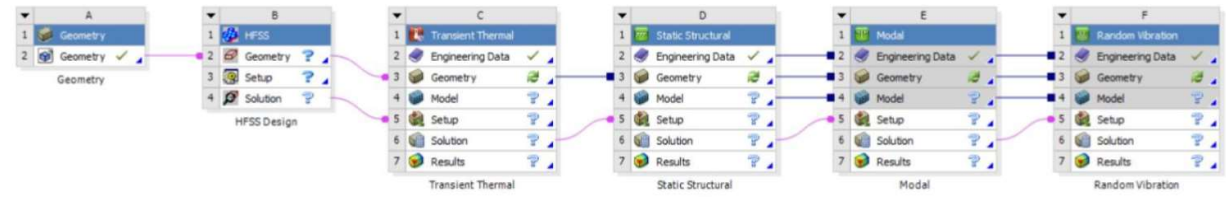


Modeling the Antenna



Transient Thermal Analysis of Satellite

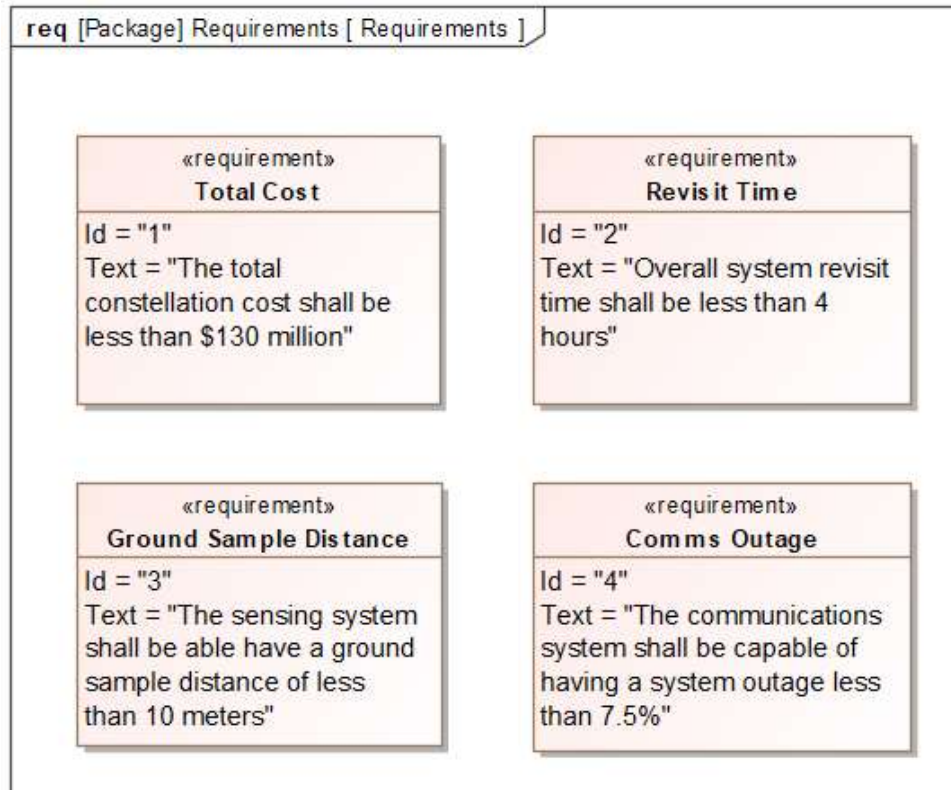
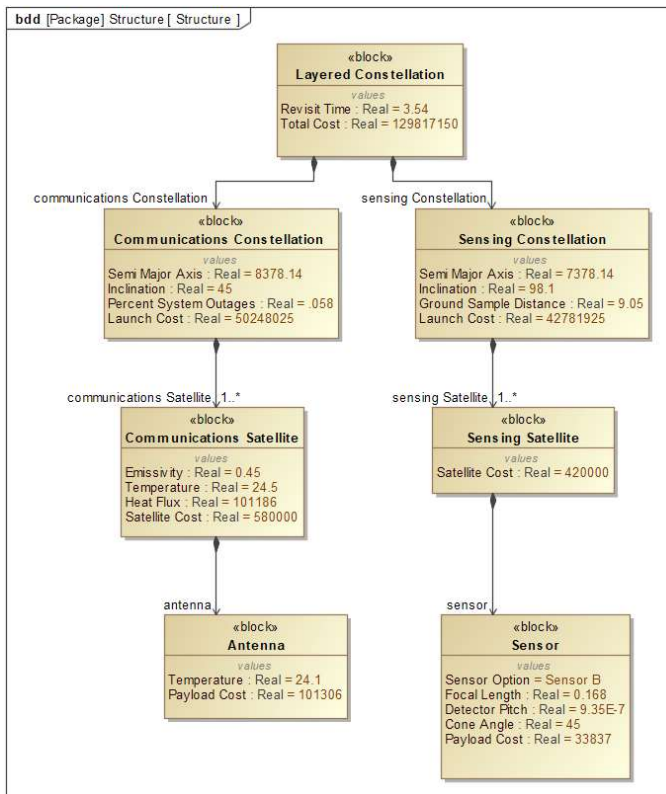
Transient Thermal Analysis



Layered Constellation Cost Spreadsheet

	A	B	C	D	E	F	G
1							
2	Satellite Cost Analysis						
3		Comms	Sensing				
4	Cost per Satellite:	\$580,000	\$420,000				
5	Launch Cost:	\$50,248,025	\$42,781,925				
6	Payload Cost:	\$101,306	\$33,837				
7	Number of Sats:	48	9				
8		TOTAL COST:	\$129,817,150				
9							
10	Comms Launch Cost				Sensing Launch Cost		
11							
12	Semi Major Axis (km) :	8378.14	\$22,000,140		Semi Major Axis (km) :	7378.14	\$16,400,140
13	Inclination (deg):	45	\$1,650,000		Inclination (deg):	98.1	\$5,359,200
14	Overhead:		\$20,000,000		Overhead:		\$15,400,000
15	Maneuver Cost:		\$6,597,885.00		Maneuver Cost:		\$5,622,585.00
16		LAUNCH COST:	\$50,248,025			LAUNCH COST:	\$42,781,925
17							
18	Comms Payload Cost Estimate				Sensing Payload Cost Estimate		
19							
20	Beamwidth(deg)	55	\$16,806			PAYLOAD COST:	\$33,837
21	Power (W):	3	\$67,500				
22	Overhead:		\$17,000				
23							
24		PAYLOAD COST:	\$101,306				

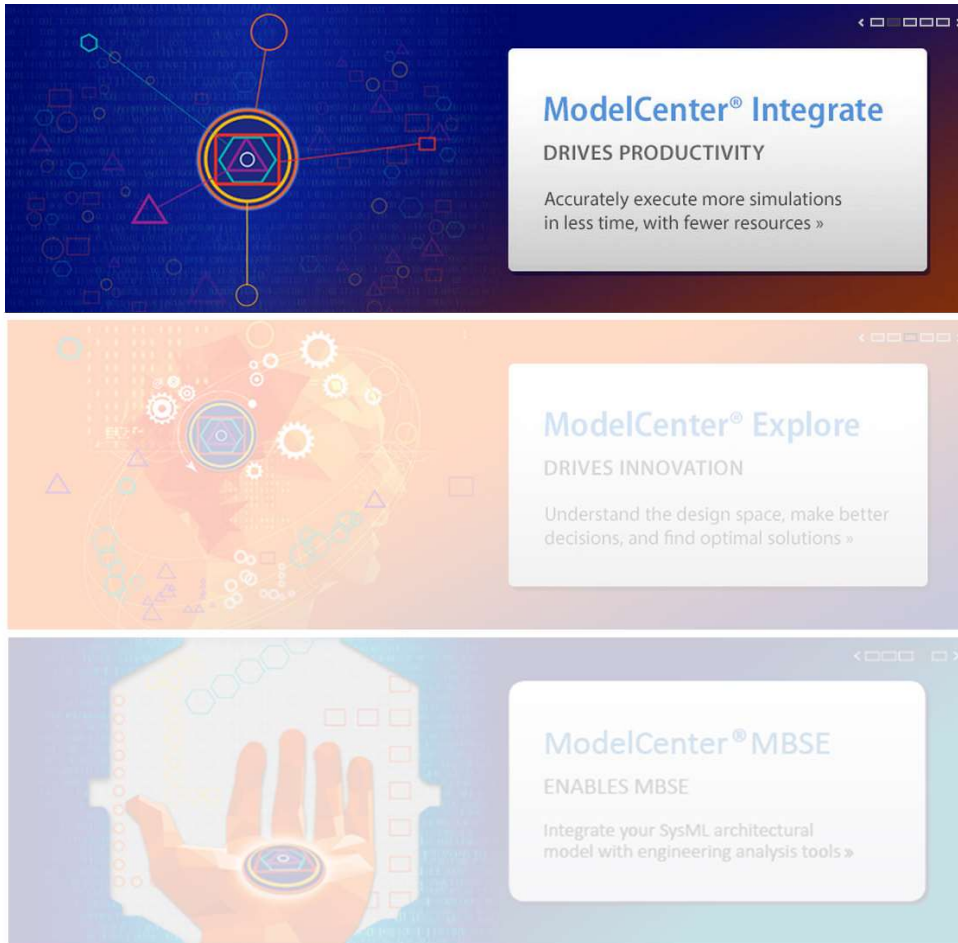
Cameo SysML Model





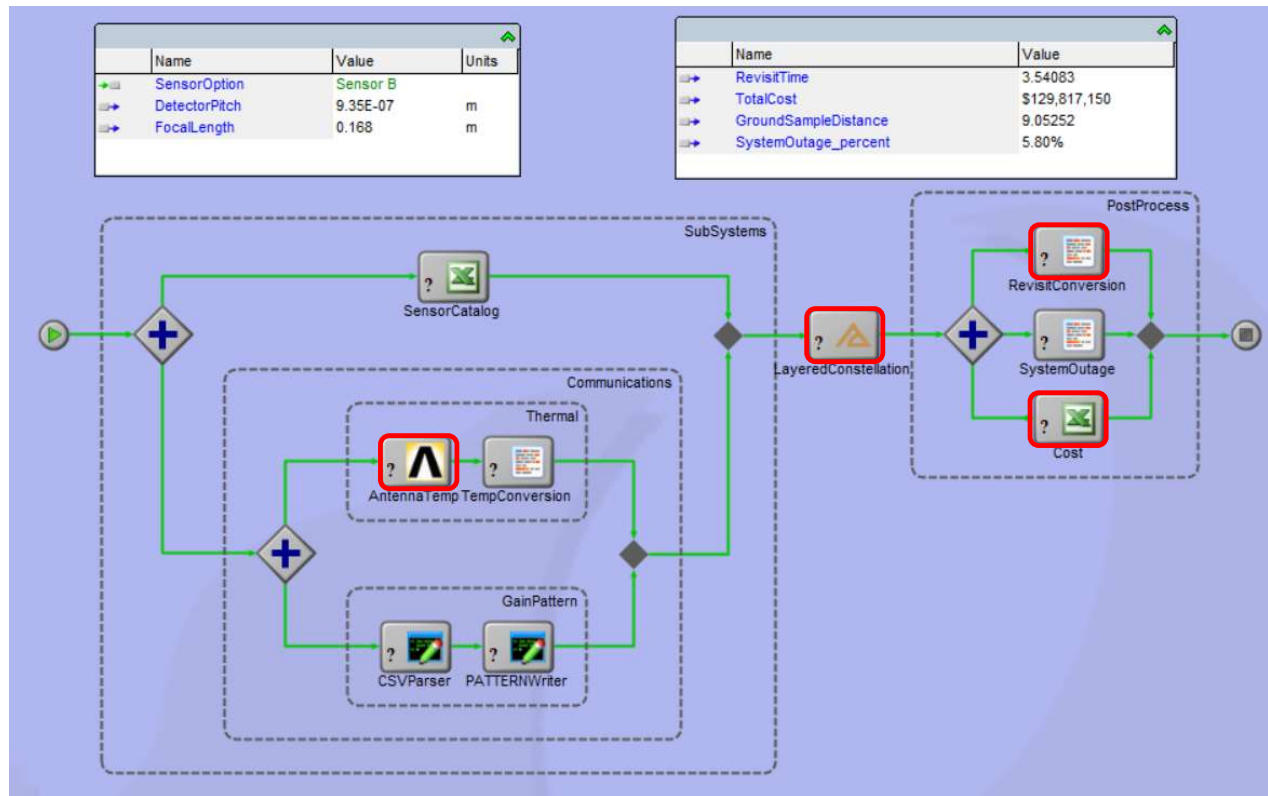
Integrate DME models into ModelCenter

Anssys



- ModelCenter Integrate
 - Automate
 - Integrate
 - To Create a Workflow

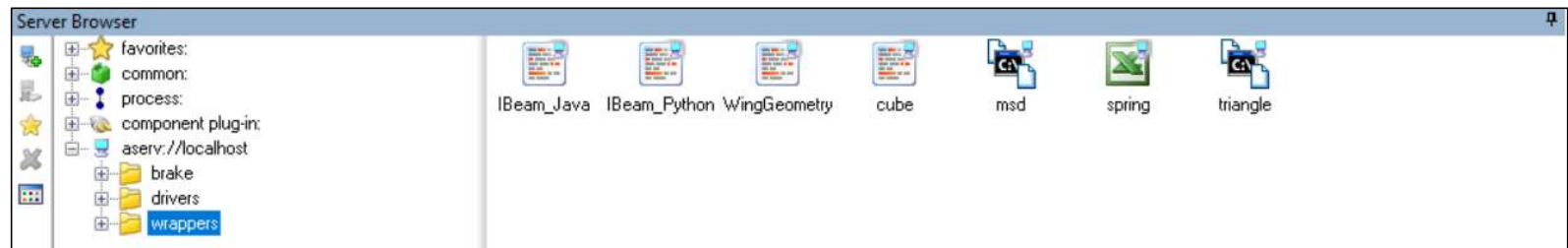
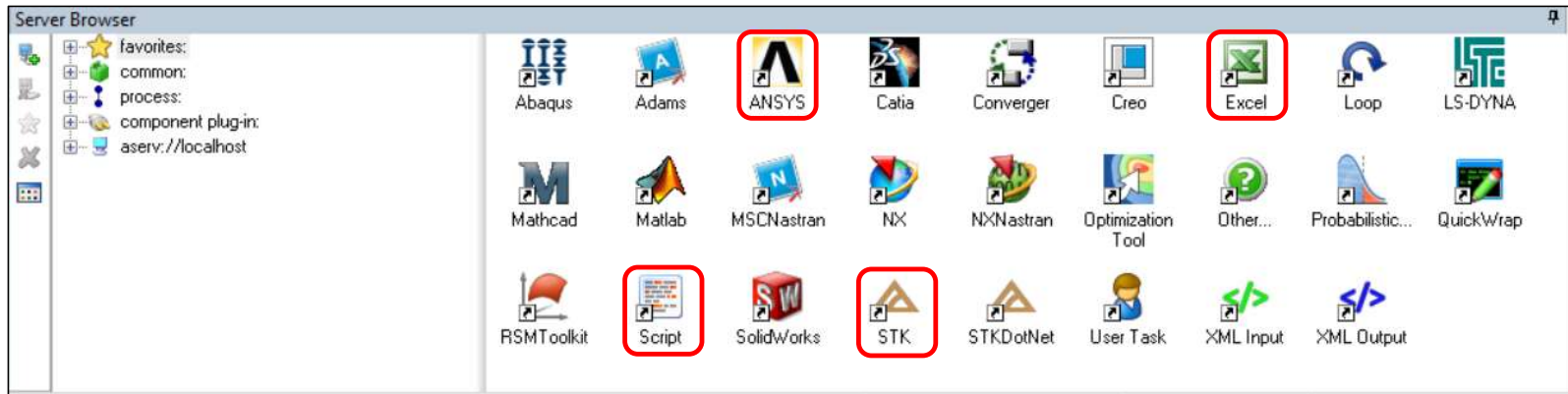
ModelCenter Wildfire Workflow



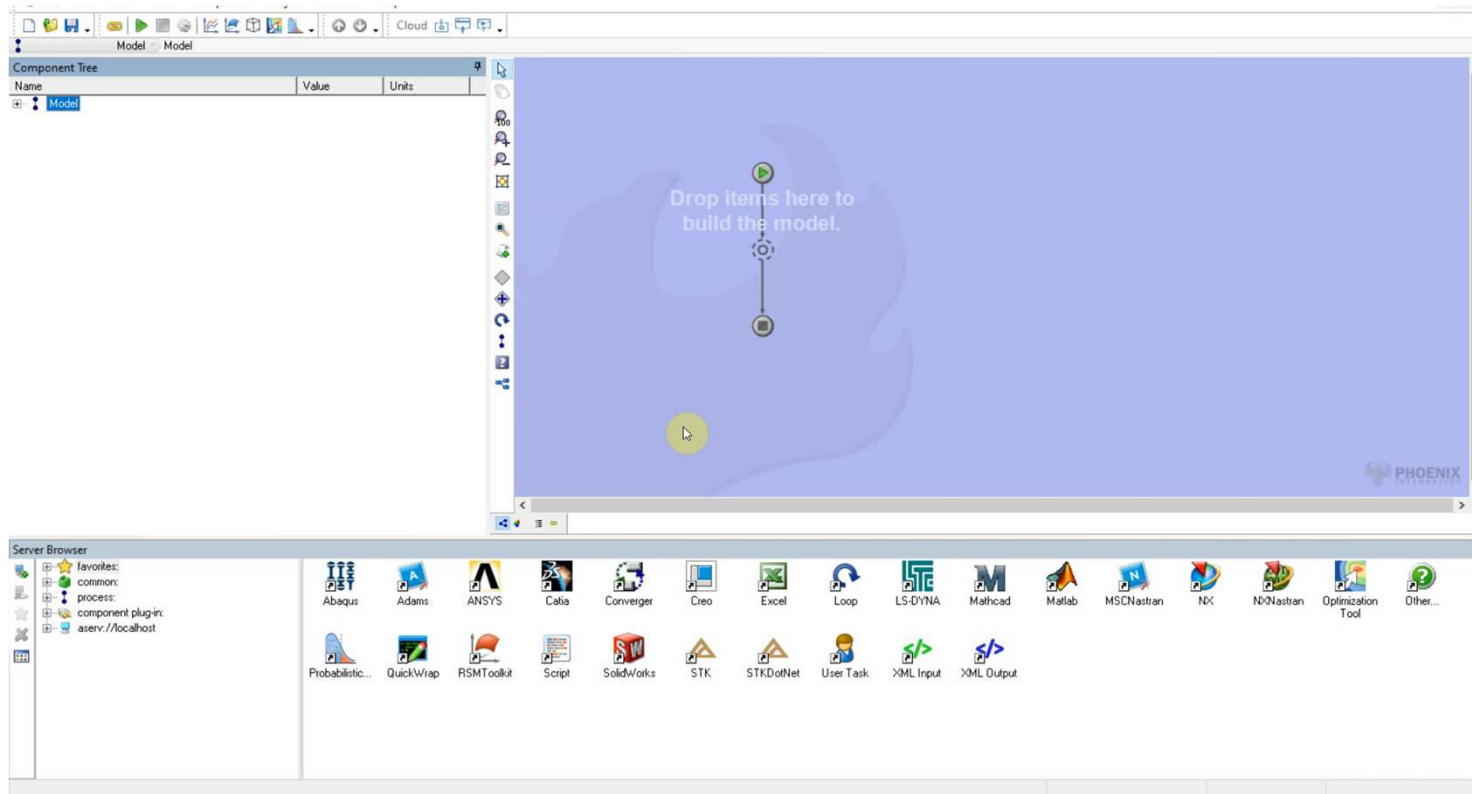
/ Automating with ModelCenter



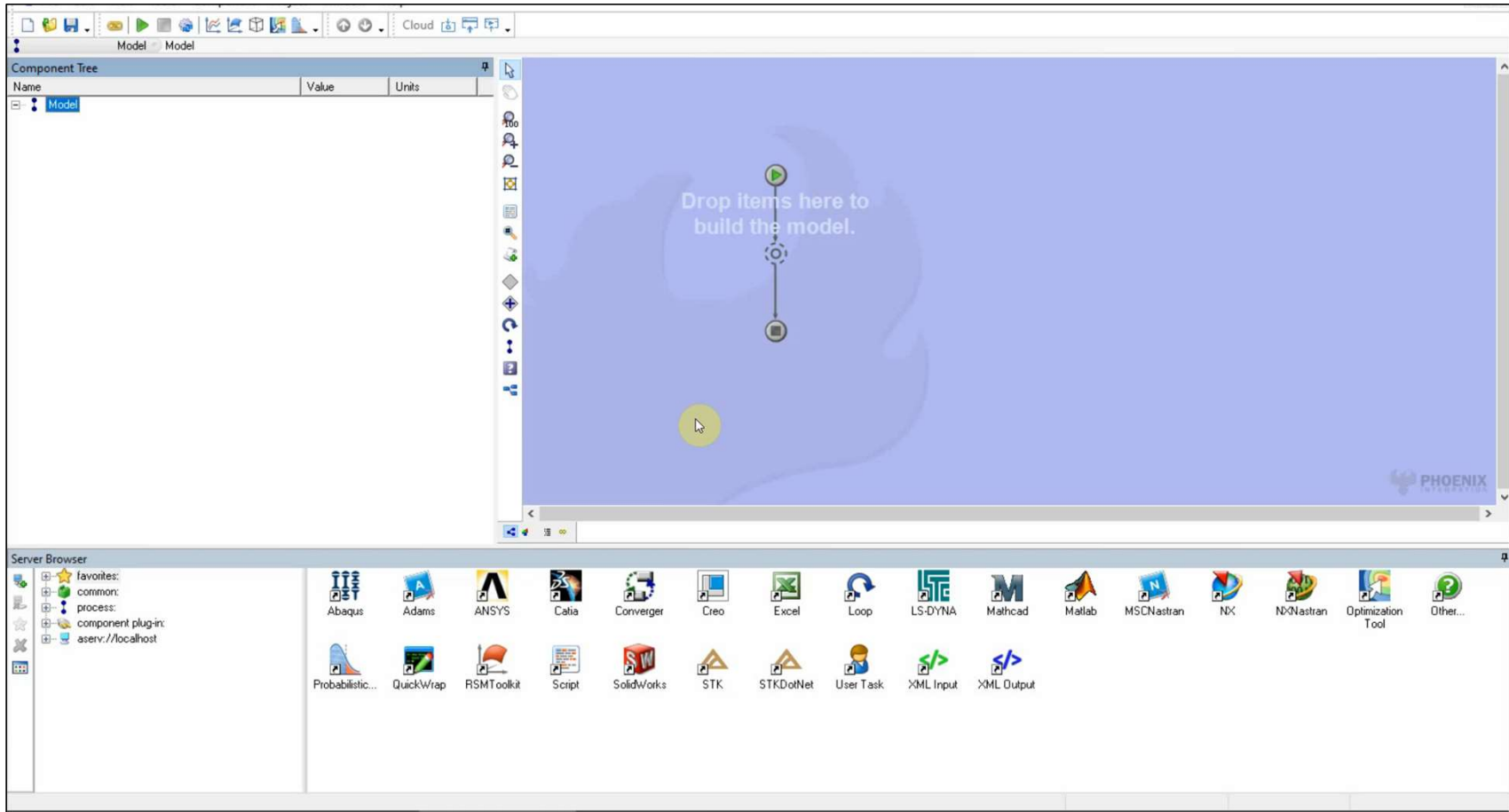
Automating with ModelCenter



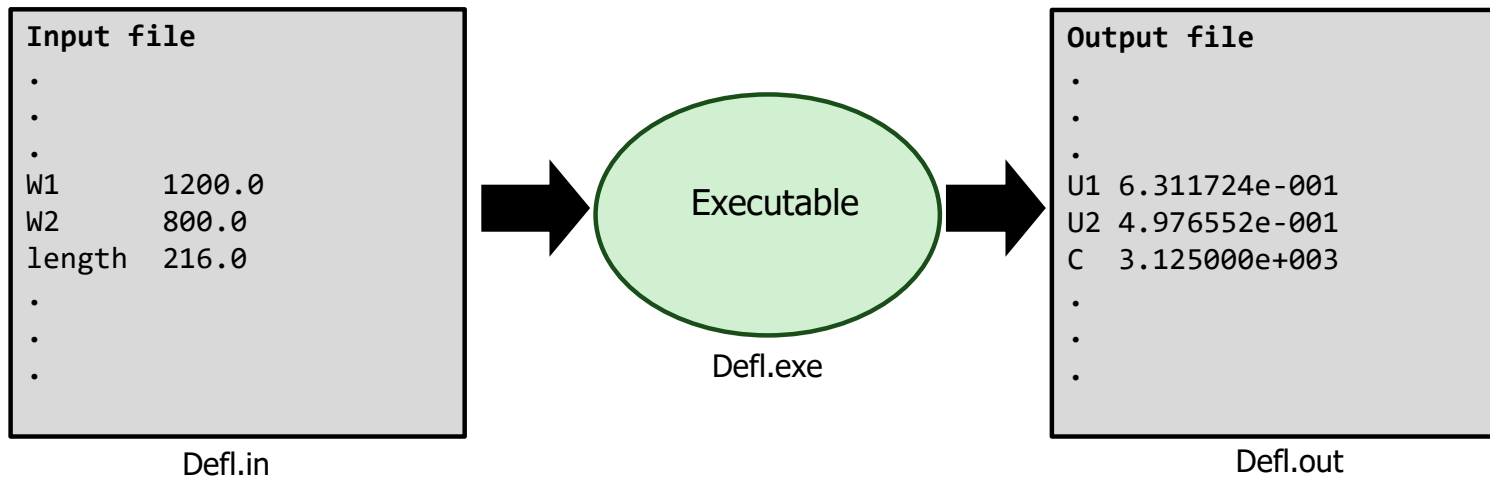
Demo: Automating Excel



Demo: Automating STK



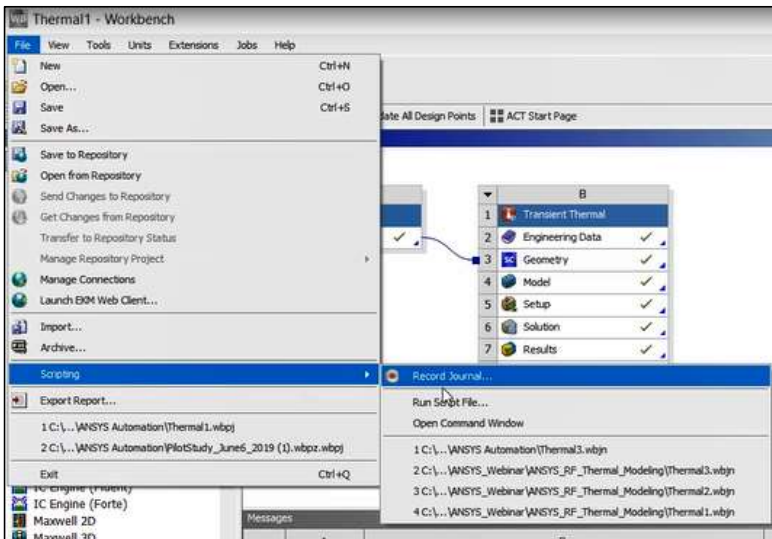
/ Automating File I/O



```
C:\>"C:\Users\sjohnson\Documents\PHX Trainings\Defl.exe" -i Defl.in -o Defl.out
```

Automating ANSYS (File I/O)

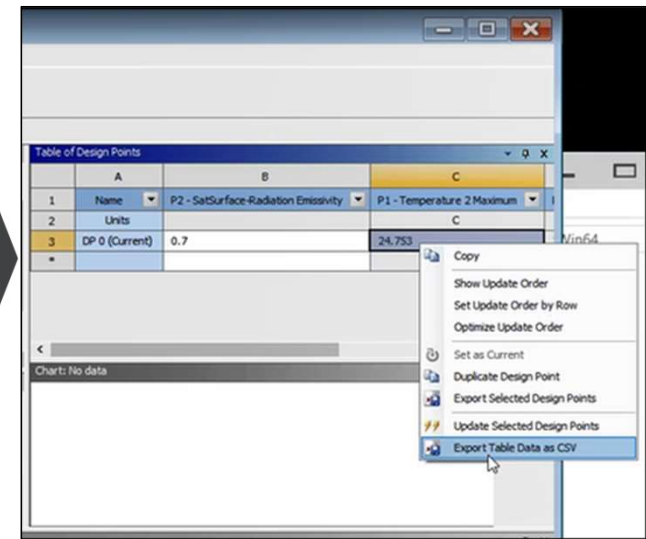
Input File



Executable

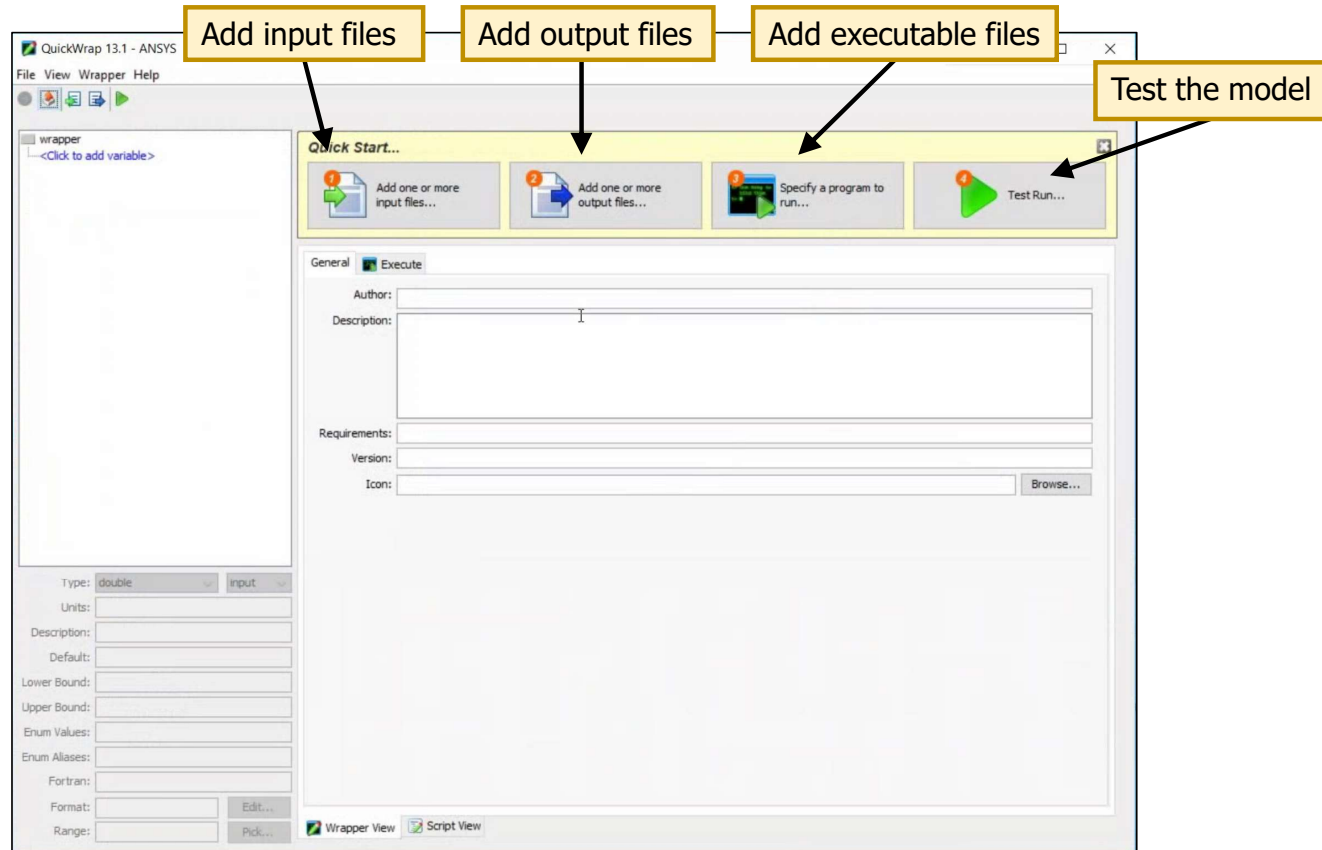


Output File

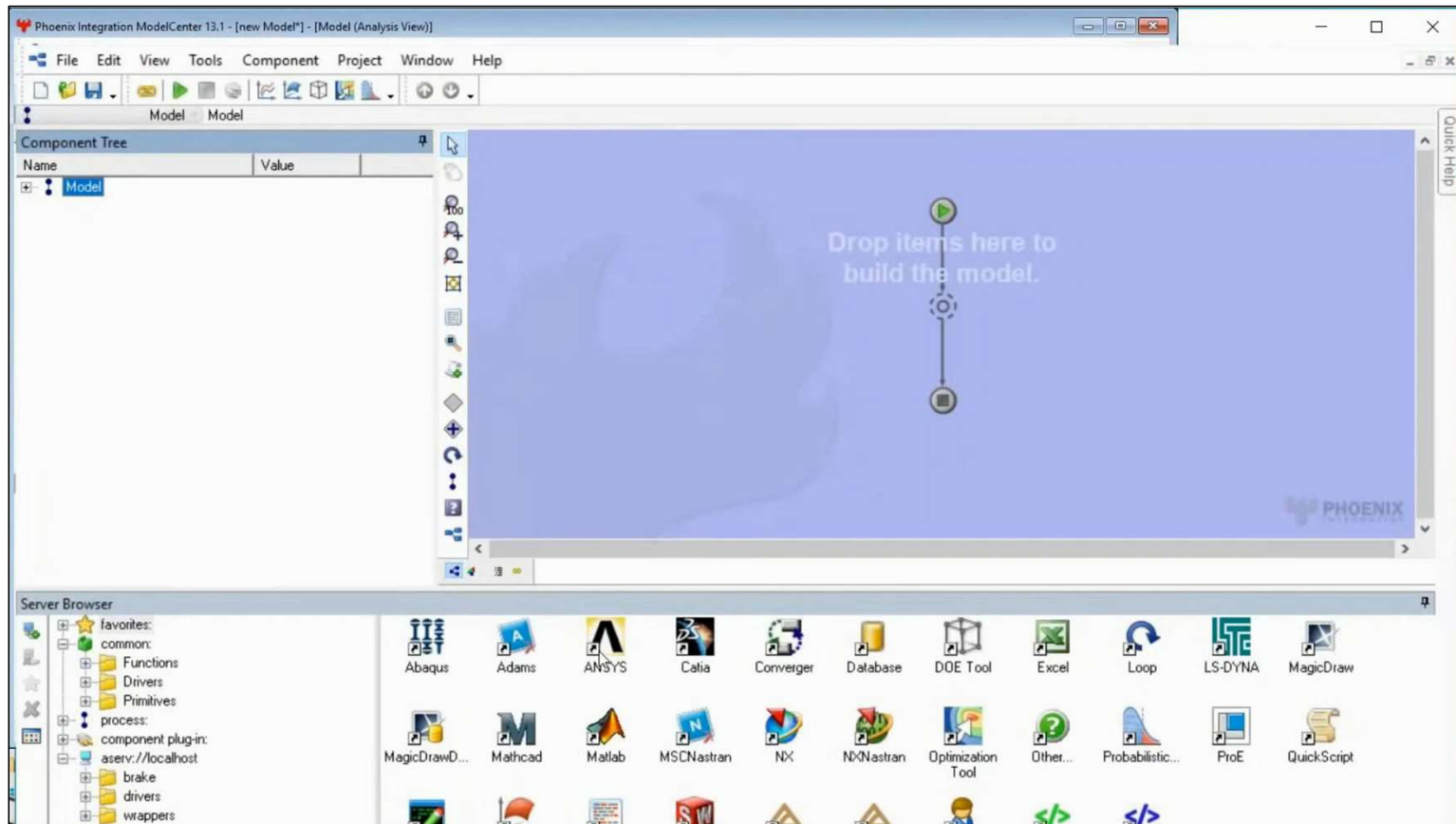


```
C:\>"C:\Program Files\ANSYS Inc\v193\Framework\bin\Win64\runwb2" -F Thermal1.wbpj -B -R Thermal3.wbjn
```

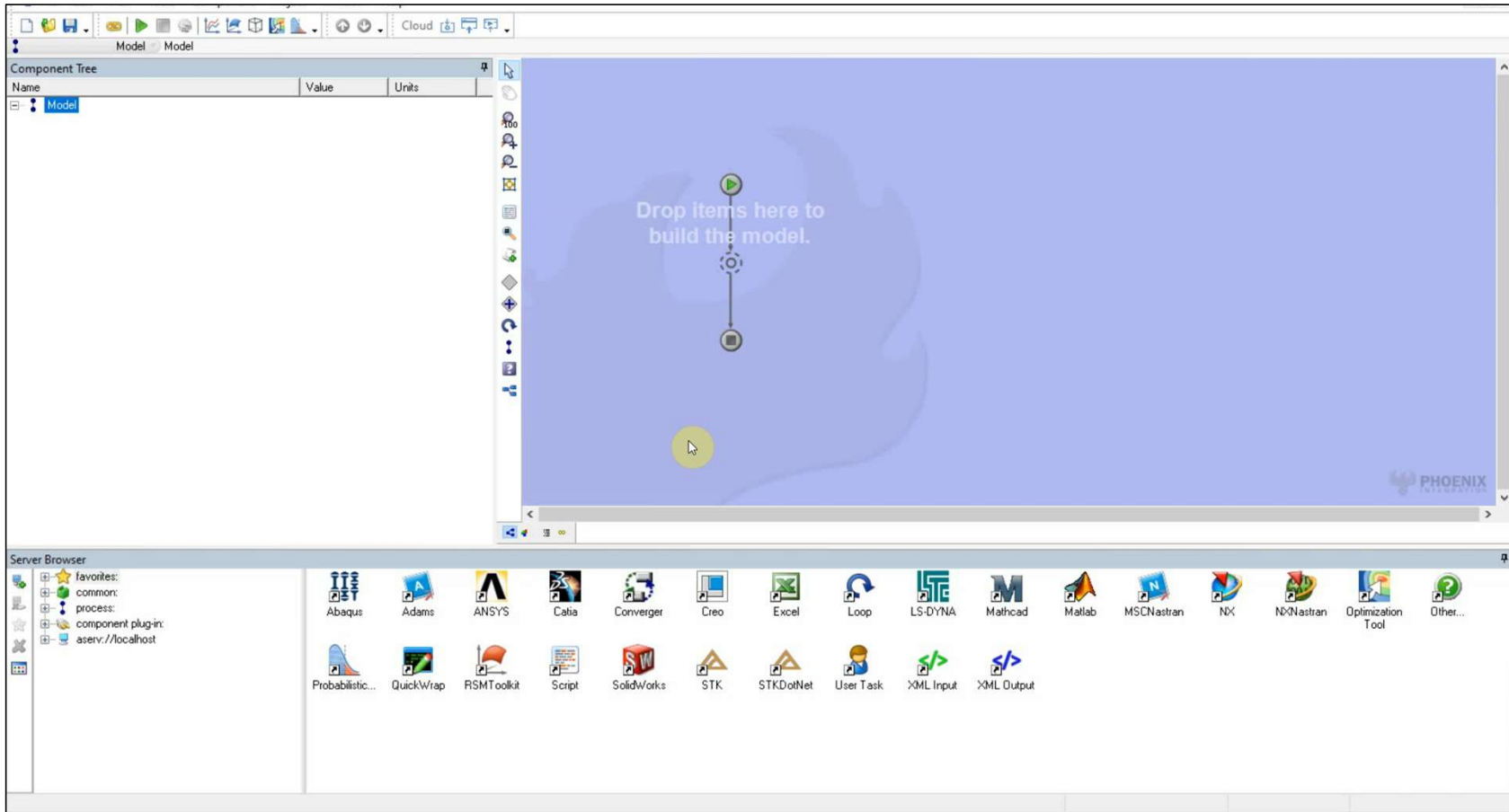
Automating ANSYS



Demo: Automating ANSYS



Demo: Automating Scripts



Demo: Executing the Wildfire Workflow

The screenshot displays the Ansys ModelCenter interface. On the left is the Component Tree, which lists various components and their values. The main workspace shows a workflow diagram with sub-systems like Communications, Thermal, and GainPattern, leading to a LayeredConstellation and PostProcess stages. Two data tables are overlaid on the workspace, showing parameter values and simulation results.

Name	Value	Units
SensorOption	Sensor A	
DetectorPitch	9.35E-07	m
FocalLength	0.168	m

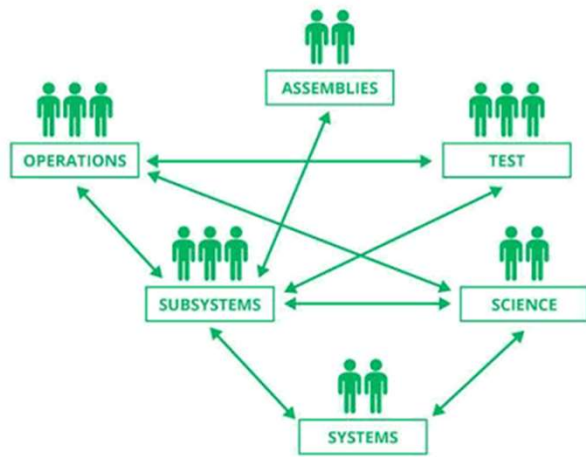
Name	Value
RevisitTime	3.52864
TotalCost	\$129,817,150
GroundSampleDistance	8.95961
SystemOutage_percent	7.06%



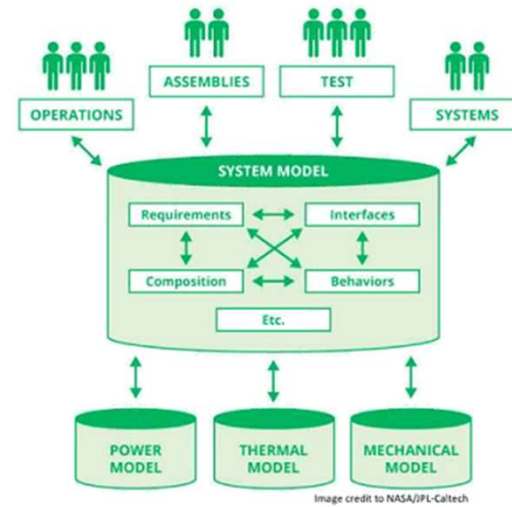
**Connect ModelCenter
workflow to Cameo SysML
model**

Ansys

MBSE in a Nutshell



Traditional Systems Engineering



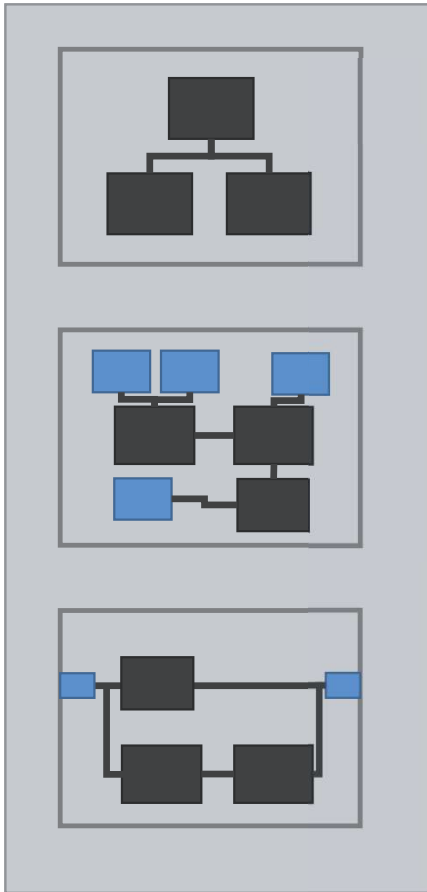
Model Based Systems Engineering



- ModelCenter Integrate
 - Automate
 - Integrate
 - To Create a Workflow
- ModelCenter Explore
 - Iterate The Workflow
 - Design Studies
 - Optimizations
 - Risk/Reliability
- ModelCenter MBSE
 - Integrate **Systems Engineering** Models with **Analytical** Models.

Ansys / ModelCenter®

System Model

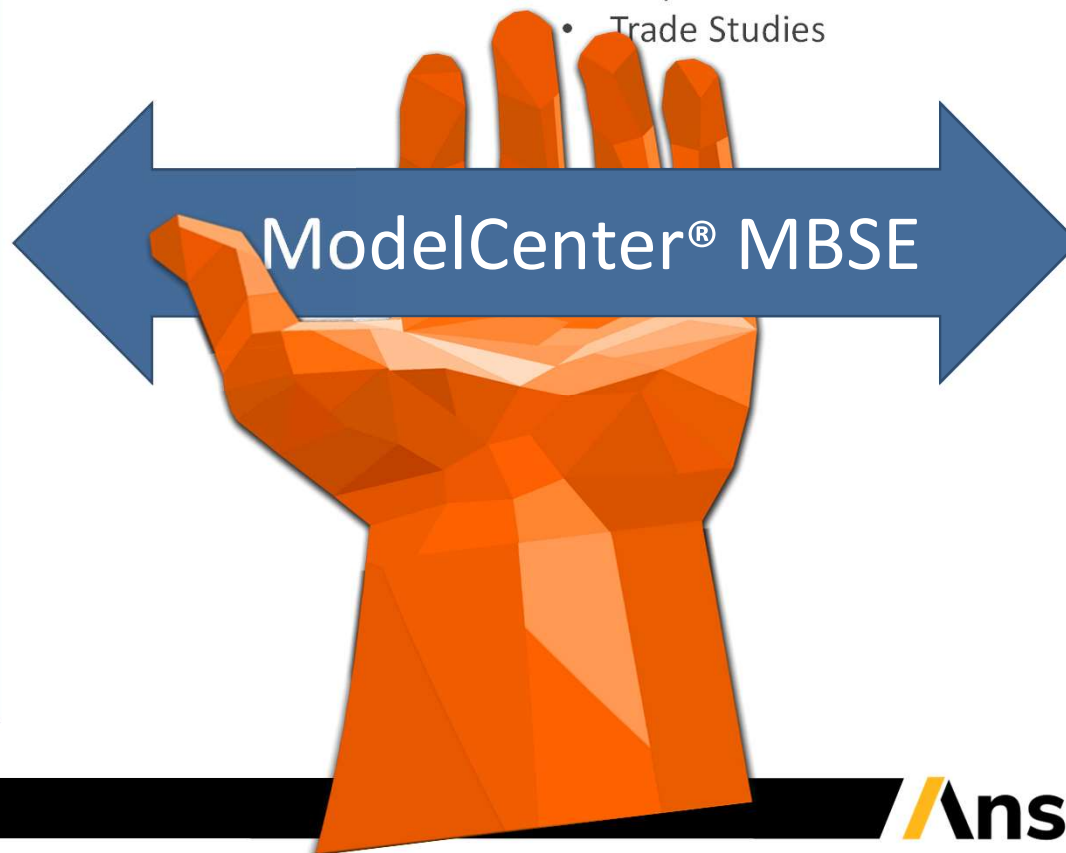


Descriptive

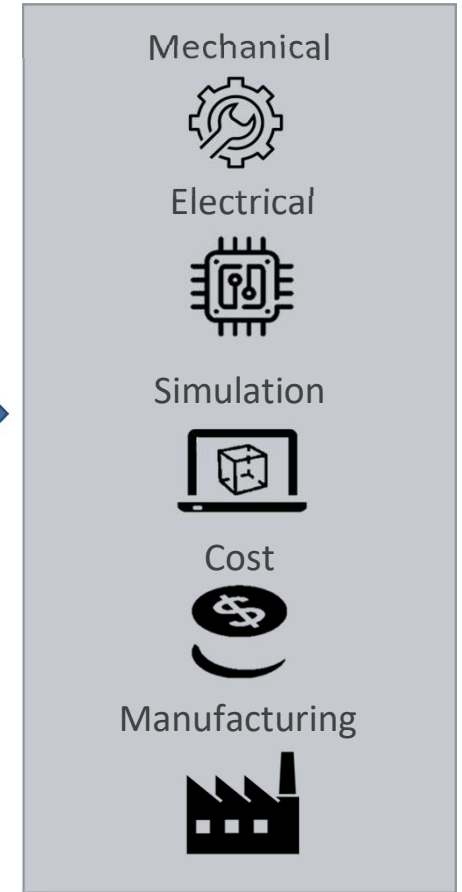
- Behavior
- Requirements
- Structure

Dynamic, Low to High-Fidelity Models

- Behavior Simulation
- Requirements Verification
- Trade Studies



ModelCenter®



ModelCenter MBSE

The image displays the ModelCenter MBSE interface, illustrating the configuration of an analysis server for a turbomachinery model. The central window is the **Analysis Editor**, which is set to **Analysis Server** mode. It shows the **Server Address** as `aserv://localhost` and the **Current Path** as `aserv://localhost/magicDrawtraining/calc_SpecificThrust`. The **Server Browser** shows the local server structure.

The **Map Analysis Variables** section is the primary focus, showing a mapping between the **Systems Model Structure** and the **Analysis Variables**. The **Systems Model Structure** lists various components and their requirements, such as **specific thrust**, **atmospheric Condition**, **turbine**, **nozzle**, **fuel heating value**, **Mach number**, **thrust**, **mass flow rate**, **fan bypass ratio**, **fan**, **burner**, **compressor**, **LPCompressor**, **thrust specific fuel co**, **Turbine**, **Compressor**, **Burner**, **Atmospheric Condition**, **ambient temperature**, and **specific heat ratio**. The **Analysis Variables** list includes **calc_SpecificThrust** (parent) and its children: **nozzle_Vel**, **BPR**, **fan_Exit_Vel**, **Mach**, **gamma**, **R**, **Ta**, **fuelRatio**, and **specific_Thrust**.

Arrows indicate the mapping from the systems model requirements to the analysis variables. For example, **specific thrust** is mapped to **specific_Thrust**, **atmospheric Condition** to **ambient temperature**, and **fuel heating value** to **fuelRatio**.

On the left, a partial view of the **Model Structure** shows a hierarchical tree of components like **LPCompressor**, **HPCompressor**, **compressor**, **nozzle**, **fan**, **burner**, and **turbine**. On the right, a **Value** table shows parameters like **height** (10), **width** (50), and **displacement** (1.45E+03). Below this, a **Sequence** diagram shows a flow from **ANSYS** to **yieldTester** via a **cost** block, with a **Parallel1** block also connected.

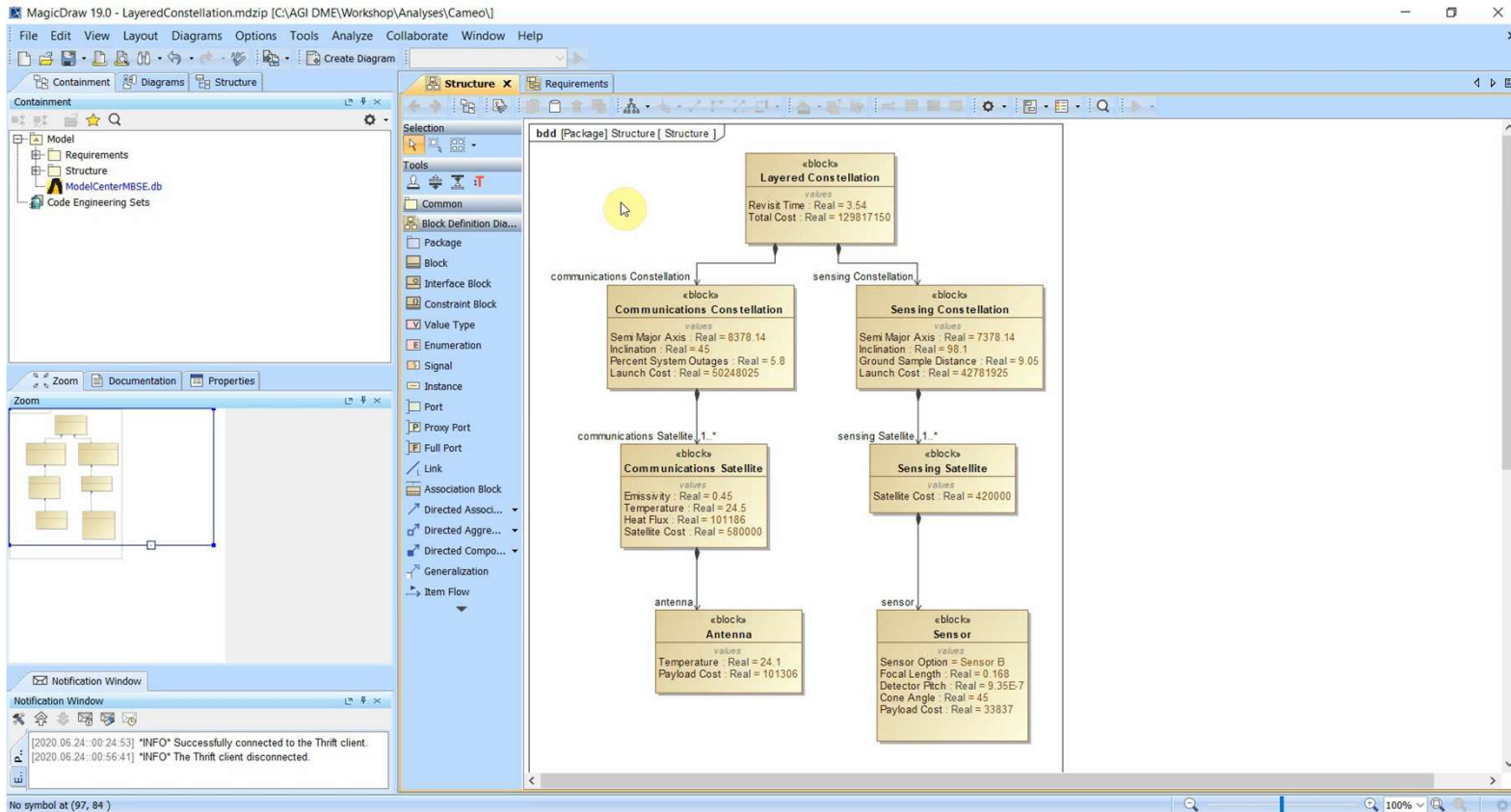
ModelCenter MBSE

The screenshot displays the Ansys ModelCenter MBSE interface. The main window shows a 'Results' table with columns for Name, Initial Value, Value, Change, Delta, and Delta %. The table is organized into a tree structure under 'Data' and 'Structure'. A yellow callout box highlights the 'Tire' row. A yellow box at the bottom center contains the text 'Design instance saved.'.

Name	Initial Value	Value	Change	Delta	Delta %
heat	52.704	50.752	↓	1.95	3.7037
surfaceArea	6.0000	9.0000	↑	3.00	50.000
width	3.0000	3.0000	=	0.0	0.0
life	36016	56102	↑	200	55.765
brakeMU	0.80000	0.80000	=	0.0	0.0
effectiveRadius	4.5000	4.0000	↓	0.50	11.111
centerLength	3.0000	3.0000	=	0.0	0.0
thickness	0.27500	0.27500	=	0.0	0.0
normalForce	1687.1	1687.1	=	0.0	0.0
torque	506.14	449.91	↓	56.2	11.111
od	11.000	11.000	=	0.0	0.0
diameter	22.000	22.000	=	0.0	0.0
speed	65.000	65.000	=	0.0	0.0

Name	Satisfied	Margin
2 Brake Heating	✓	2.2480

Demo: Integrating SysML with ModelCenter MBSE



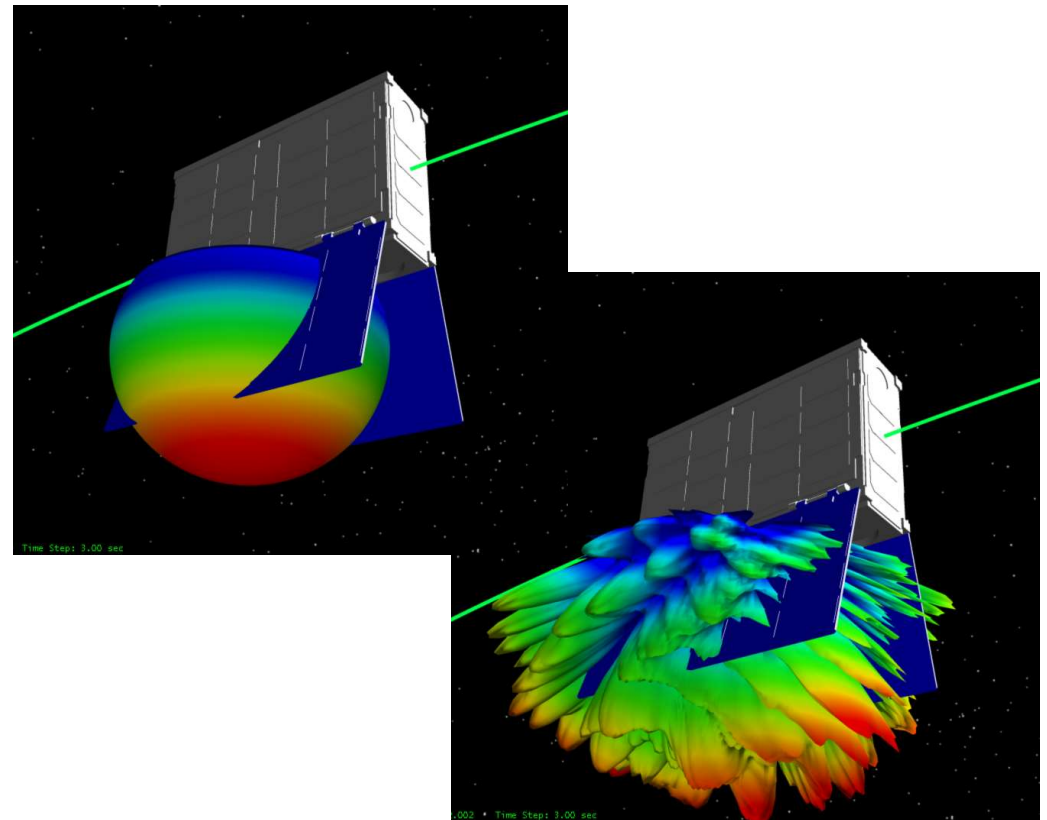
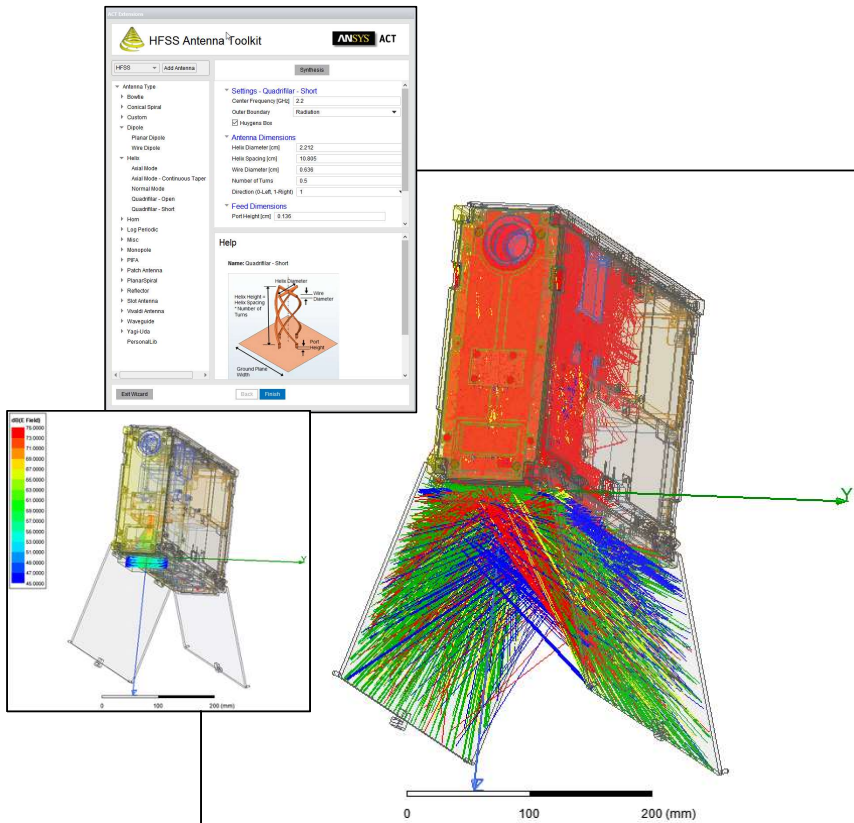


**Increase the fidelity of the
antenna pattern for STK**



Ansys

Installed Performance: Capturing the Cubesat Interaction



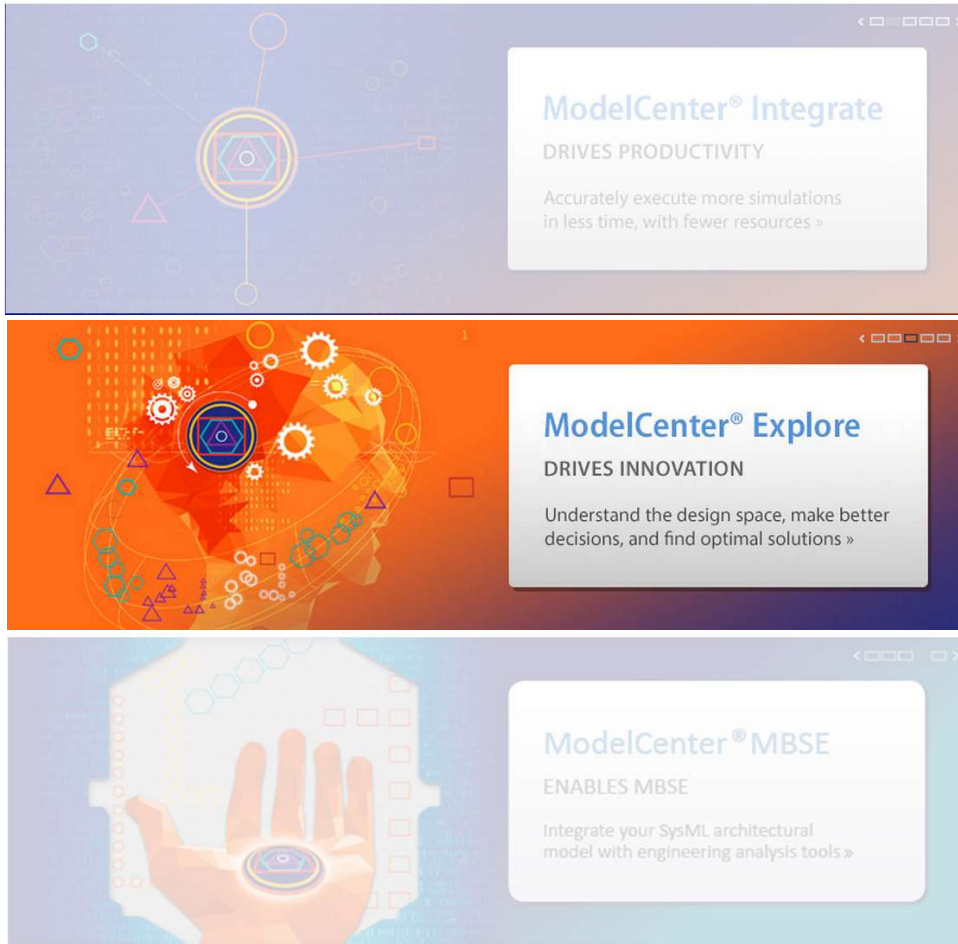


**Handle requirements
changes in the SysML
model**

Ansys

Mission Requirements Change

1. The sensing system shall collect imagery with a **ground sample distance** less than **6 meters** in order to detect any wildfire in North America greater than **1 acre**
2. The communications system shall provide link availability with less than **7.5% outage** which corresponds roughly to one orbital period per day
3. Overall system **revisit time** shall be less than **4 hours** to support an adequate response time
4. **Total cost** shall be less than **\$130 million**



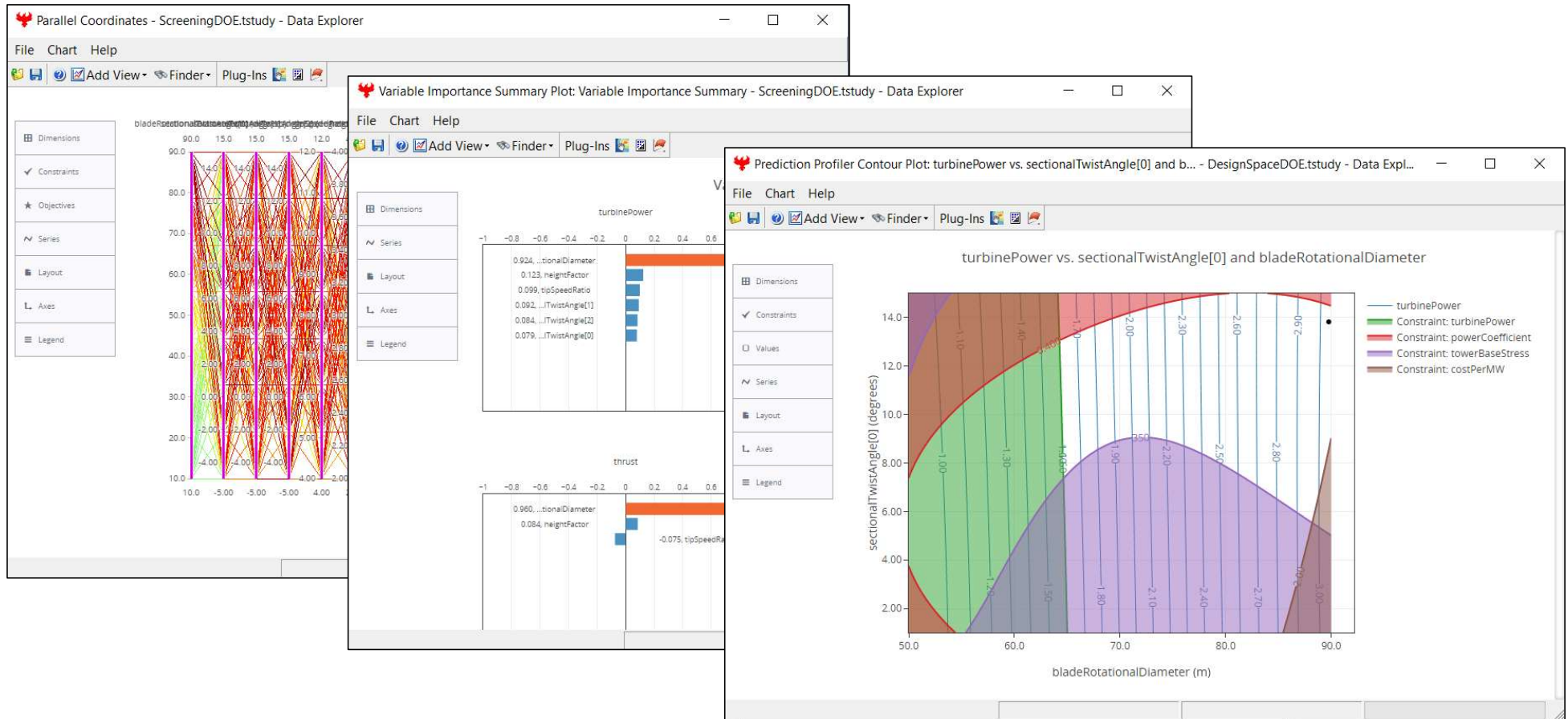
- ModelCenter Integrate
 - Automate
 - Integrate
 - To Create a Workflow

- ModelCenter Explore
 - **Iterate** The Workflow
 - Design Studies
 - Optimizations
 - Risk/Reliability

- ModelCenter MBSE
 - Integrate **Systems Engineering** Models with **Analytical** Models.



ModelCenter Explore



Design Exploration in ModelCenter MBSE

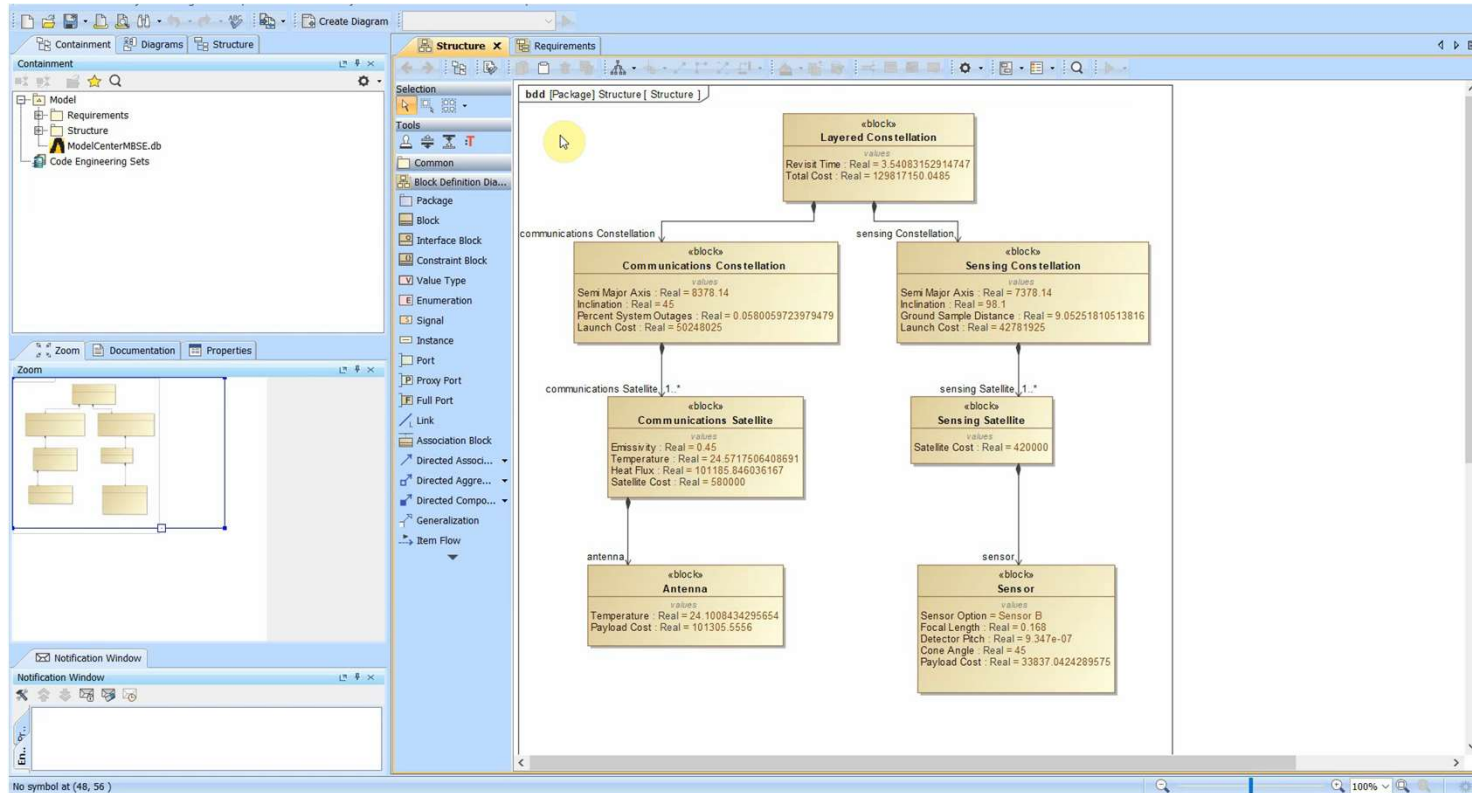
The screenshot displays the ModelCenter MBSE interface with the DOE tool open. The 'New Trade Study' menu is expanded, and 'DOE' is highlighted. The 'Structure Elements' table lists the following data:

Name	Value
Revisit Time	3.54083152914
Total Cost	129817150.048
Sensing Satellite	
Satellite Cost	420000
Sensing Constellation	
Launch Cost	42781925
Ground Sample Distance	9.05251810513
Communications Satellite	
Temperature	24.5717506408
Emissivity	0.45
Heat Flux	101185.846036
Satellite Cost	580000
Communications Constellation	
Launch Cost	50248025
Percent System Outages	0.05800597239
Sensor	
Detector Pitch	9.347e-07
Focal Length	0.168

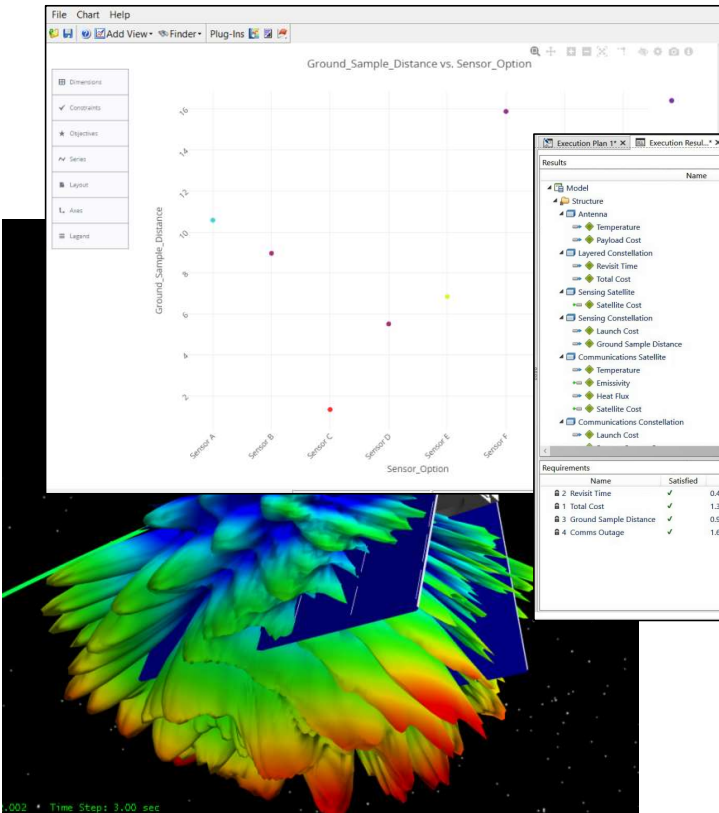
The 'DOE Tool 2.3.1' window shows the following configuration:

- Design Variables: Model.Inputs.Model.Structure.Sensor.Sensor_Option (Enumerated: "Sensor A", "Sensor B")
- Response Variables: Model.Outputs.Model.Structure.Layered_Constellation.Revisit_Time, Model.Outputs.Model.Structure.Layered_Constellation.Total_Cost, Model.Outputs.Model.Structure.Sensing_Constellation.Ground_Sample_Distance, Model.Outputs.Model.Structure.Communications_Constellation_Percent_System_Outages
- Design: Parameter Scan
- Status: Runs: 8

Demo: Handling Requirement Changes



Demo Summary



Execution Plan 1* X Execution Result* X

Completed: 6/24/2020 1:37:54 AM

Name	Initial Value	Value
Temperature	24.1	24.1008434295654
Total Cost	101306	101305.5556

Systems Model Structure

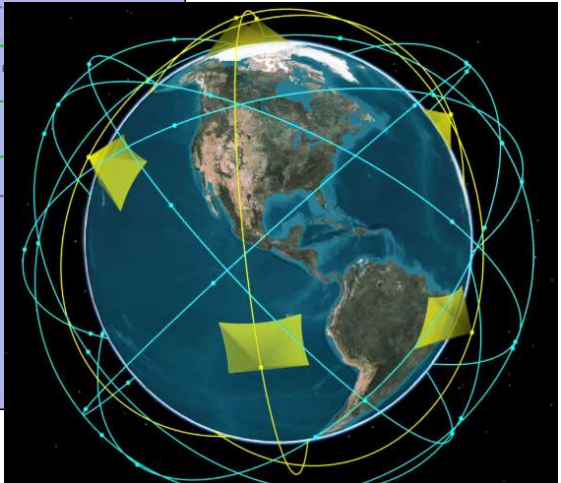
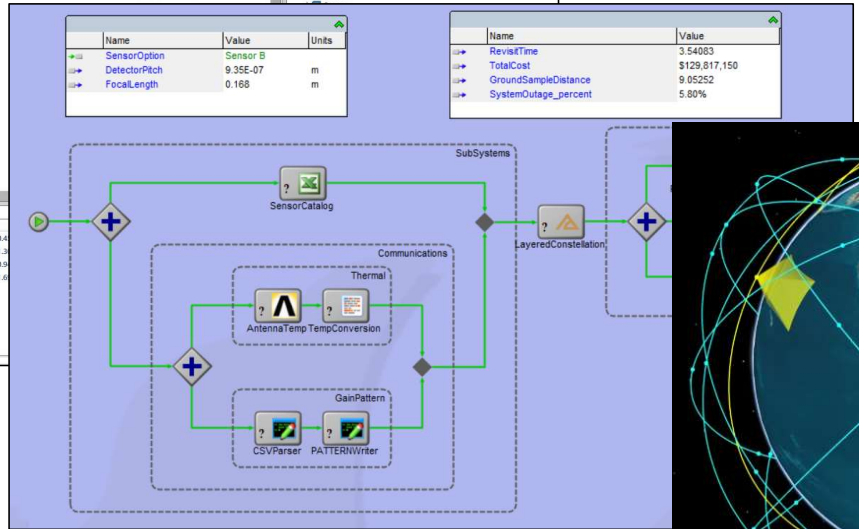
- Model
 - Structure
 - Sensing Satellite
 - Layered Constellation
 - Communications Satellite
 - Sensing Constellation
 - Communications Constellation
 - Antenna

Name	Value	Units
SensorOption	Sensor B	
DetectorPitch	9.35E-07	m
FocalLength	0.168	m

Name	Value
RevisitTime	3.54083
TotalCost	\$129,817,150
GroundSampleDistance	9.05252
SystemOutage_percent	5.80%

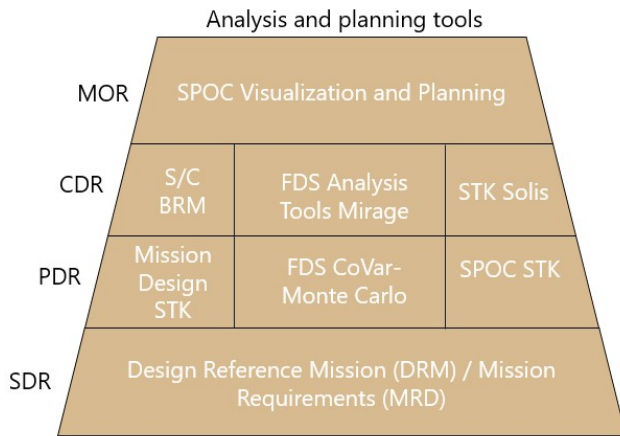
Requirements

Name	Satisfied
2 Revisit Time	✓ 0.4
1 Total Cost	✓ 1.3
3 Ground Sample Distance	✓ 0.8
4 Comms Outage	✓ 1.6



OSIRIS-Rex

Digital Mission Engineering Case Study



Tools used to optimize the time line
<https://ntrs.nasa.gov/citations/20150002855>



Rick Ambrose • 2nd
 Executive Vice President of Lockheed Martin Space | LinkedIn Top Voice in Tech...
 1d • Edited •

The OSIRIS-REx spacecraft had a successful rendezvous with the asteroid Benu! The spacecraft's robotic arm briefly touched the asteroid, deployed nitrogen to collect a pristine sample, and successfully backed away from the asteroid. In the coming weeks, we'll learn whether or not the attempted sample collection was a success, but this was certainly a significant milestone to reach – especially at 207 million miles away from Earth. Congratulations to the team! [#ToBennuAndBack](#)

<https://www.agi.com/blog/2020/10/tagging-asteroid-bennu>

<https://www.phoenix-int.com/integrated-model-based-systems-engineering-mbse-applied-simulation-osiris-rex-mission-lockheed-martin-space/>

APPROACH

SysML Model + MBSE Analyzer

#	Name	Default Value
1	AnalysisStartTime	12 Nov 2018 00:00:00.000
2	AnalysisStopTime	13 Nov 2018 00:00:00.000
3	IntervalSize	43200
4	StepSize	3600

Simulation Settings & Constraints

STK Simulation Results

Systems Tool Kit (STK)

ModelCenter

STK & MC Simulation Results

Data Explorer

- Overview
- Challenges
- Objectives
- Approach
- Modeling
- Simulating
- Results
- Reflections
- Future Work

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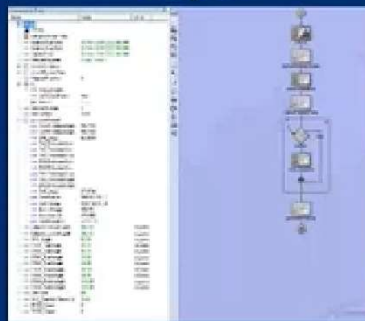


Ansyes technology was an essential part of the Design Reference Mission, through PDR, CDR and for Operations. True Digital Mission Engineering from concept through operations.

SIMULATION PROCESS OVERVIEW

- Overview
- Challenges
- Objectives
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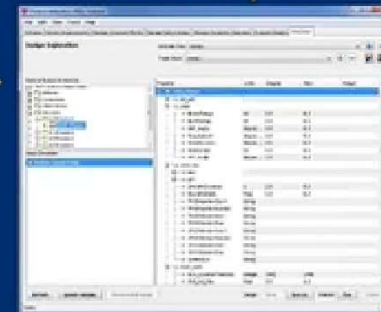
6. Evaluate STK parameters;
return results to MBSE
Analyzer.



1. Enter simulation settings
and constraints.

#	Name	Default Value
1	AnalysisStartTime	12 Nov 2018 00:00:00.000
2	AnalysisEndTime	00:00:00.000
3	Interval	00:00:00.000
4	StepSize	00:00:00.000

2. Initiate simulation from
MBSE Analyzer.



7. Display simulation results for
each time step.

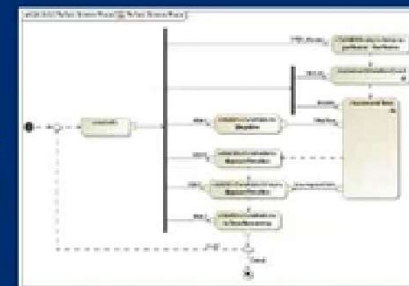
5. Retrieve parameter
values from STK.



4. Point to external
analysis tools.



3. Step through the mission
simulation.



Integrated Model Framework Example

Descriptive to Analytical and Back



***Integrated Model
Framework***

eCenter®